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WEEKLY 6 September 2025

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THE DRAMATIC SPREAD OF THE DEATH CAP MUSHROOM

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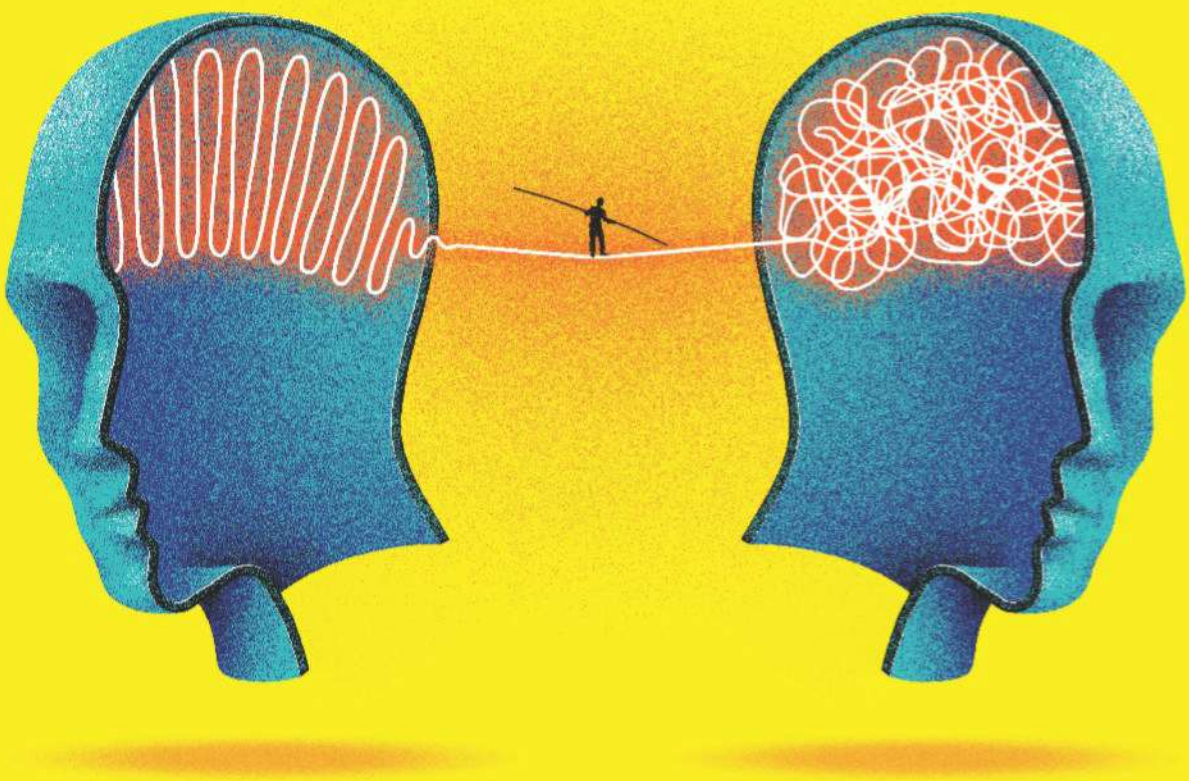

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Fighting the wrong war

Governments wanting to ban social media but embrace AI are letting teens down

IF YOU are in your 70s, you didn't fight in the second world war. Such a statement should be uncontroversial, given that even the oldest septuagenarian today was born after the war ended. But there remains a cultural association between this age group and the era of Vera Lynn and the Blitz.

A similar category error exists when we think about parents and technology. Society seems to have agreed that social media and the internet are unknowable mysteries to parents, so the state must step in to protect children from the tech giants, with Australia releasing details of an imminent ban (see page 8). Yet the parents of today's teenagers are increasingly millennial digital natives. Somehow, we have decided that people who grew up using MySpace or Habbo Hotel are today unable to navigate how their children use TikTok or *Fortnite*.

Simple tools to restrict children's access to the internet already exist, from adjusting router settings to requiring parental permission to install smartphone apps, but the consensus among politicians seems to be that these require a PhD in electrical engineering, leading to blanket illiberal restrictions. If you customised your Facebook page while at university, you should be able to tweak a few settings. So, rather than asking everyone to verify their age and identify themselves online, why can't we trust parents to, well, parent?

"If you customised your Facebook page at university, you should be able to tweak a few settings"

Failing to keep up with generational shifts could also result in wider problems. As with the pensioners we've bumped from serving in Vietnam to storming Normandy, there is a danger in focusing on the wrong war. While politicians crack down on social media, they rush to embrace AI built on large language models, and yet it is this technology that will have the largest effect on today's teens, not least as teachers wonder how they will be able to set ChatGPT-proof homework.

Rather than simply banning things, we need to be encouraging open conversations about social media, AI and any future technologies, both across society and within families. ▮

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SEAN GALLUP/GETTY IMAGES

Environment

Icy giant is on a losing streak

This stream of meltwater on the Rhône glacier in Switzerland has been dyed pink by a team of researchers and students from the Swiss Federal Institute of Technology in Zurich. The idea is to create a visual aid that helps them better monitor the water's rate of flow. This glacier has lost around 60 per cent of its volume since 1850 and, like most such alpine features, is threatened by rising temperatures.

Health

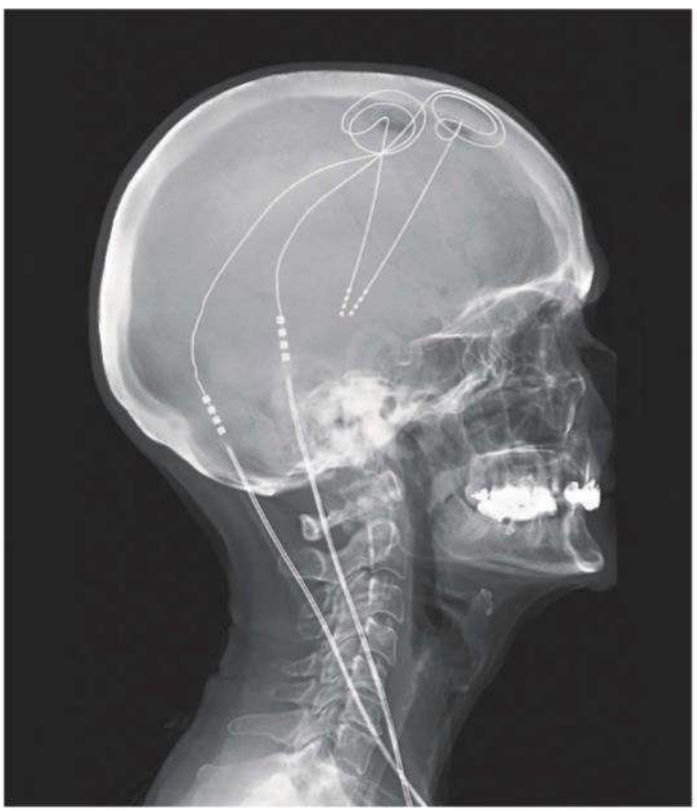
Brain implants relieve chronic pain

Tiny electrodes that monitor brain activity and provide personalised stimulation halved the discomfort of people living with chronic pain, finds **Helen Thomson**

A BRAIN implant that detects when someone is in pain and responds with deep brain stimulation has helped relieve people of previously untreatable chronic pain – with one participant even becoming able to hug his wife for the first time in years.

Chronic pain affects up to 20 per cent of people in the US, many of whom experience little relief from traditional pain therapies. This may be because it can result from fundamental changes to brain circuitry, which are challenging to target and remodel with standard therapies.

Deep brain stimulation (DBS), which involves stimulating the brain using tiny electrodes, has shown promise but has inconsistent results. Traditionally, the same brain areas are targeted in a one-size-fits-all approach, despite evidence suggesting that pain arises from different circuits in different people.



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Deep brain stimulation has been used to treat a variety of conditions

A bespoke treatment

So Prasad Shirvalkar at the University of California, San Francisco, and his colleagues wondered whether a personalised system would be more effective. To find out, six people with previously untreatable chronic pain underwent intracranial electroencephalography, in which electrodes recorded activity from and stimulated 14 sites across their brain over 10 days.

For five of the participants, the researchers were able to identify which sites to target and which stimulation frequency provided the greatest relief. Although one of the five didn't report significant pain relief, he did experience improved physical function and was able to hug his wife for the first time in years, which was considered meaningful enough to have him advance to the next stage of the trial.

20%
Up to this proportion of people in the US are affected by chronic pain

50%
The reduction in daily pain intensity reported by participants receiving deep brain stimulation

3.5 years
The benefits of deep brain stimulation persisted for a follow-up period of this length

The researchers then used machine learning to identify and distinguish between the electrical activity that occurred when the individuals experienced high or low levels of pain.

After this, they implanted permanent DBS electrodes into each participant, which were personalised to monitor their brain activity and deliver optimal stimulation whenever pain-related activity was detected, and to deactivate when they were asleep.

After six months of fine-tuning, each device was put to the test in a trial in which participants received either their real, personalised stimulation for three months, followed by a sham for three months, or vice versa, with the participants not being told which form of stimulation they were receiving. The sham stimulated the brain at a very low frequency in areas outside of the ideal location, and assessments of pain were collected multiple times a day throughout the trial.

On average, real stimulation reduced daily pain intensity by 50 per cent, compared with an 11 per cent pain increase with the sham. Daily step counts rose by 18 per cent during the real stimulation compared with 1 per cent during the sham. The participants also reported fewer symptoms of depression and expressed less pain that interfered with their daily lives during the real stimulation. These benefits persisted over a follow-up of 3.5 years (medRxiv, doi.org/p37n).

"This is an important study leveraging the latest tools," says Tim Denison at the University of Oxford.

A previous problem for DBS technology has been habituation, in which the brain adapts to consistent stimulation and efficacy declines. Denison says the persistent benefits might be linked to the participants only receiving stimulation when their pain levels increased, rather than it being constant. The next step would be to compare adaptive versus constant stimulation to measure differences in outcomes, he says.

"Another challenge will be economics and scaling of this technique," says Denison, which "motivates continued research in less invasive methods of neuromodulation". ▮

Artificial intelligence

Light-based AI can generate images without huge energy consumption

Alex Wilkins

AN AI image generator that uses light to produce images, rather than conventional computing hardware, could consume hundreds of times less energy.

When an artificial intelligence model produces an image from text, it typically uses a process called diffusion. The AI is first shown a large collection of images and shown how to destroy them using statistical noise, then it encodes these patterns in a set of rules. When it is given a new, noisy image, it can use these rules to do the same thing in reverse: over many steps, it works towards a coherent image that matches a given text request.

For realistic, high-resolution images, diffusion uses many sequential steps that require a significant level of computing power.

In April, OpenAI reported that its new image generator had created more than 700 million images in its first week of operation. Meeting this scale of demand requires vast amounts of energy and water to power and cool the machines running the models.

Now, Aydogan Ozcan at the University of California, Los Angeles, and his colleagues have developed a diffusion-based image generator that works using a beam of light. While the encoding process is digital, requiring a small amount of energy, the decoding process is entirely light-based, requiring no computational power.

"Unlike digital diffusion models that require hundreds to thousands of iterative steps, this process achieves image generation in a snapshot, requiring no additional computation beyond the initial encoding," says Ozcan.

Vincent van Gogh-style images generated by digital (left) and light-based (middle, right) AI models

SHIQI CHEN ET AL. (2025)

The system first uses a digital encoder trained using publicly available image datasets, which can produce static that can be turned into images. Then, they used this encoder with a liquid crystal screen called a spatial light modulator (SLM) that can physically imprint this static into a laser beam.

When the laser beam passes through a second decoding SLM, it instantly produces the desired image on a screen recorded by a camera.

Ozcan and his team used their system to produce black and white images of simple objects like the digits 1 to 9 or basic clothing, which are used to test diffusion models, as well as full-colour images in the style of Vincent Van Gogh. The results looked broadly similar to those produced by conventional image generators (*Nature*, doi.org/g9zqjr).

"This is perhaps the first example where an optical neural network is not just a lab toy, but a computational tool capable of producing results of practical value," says Alexander Lvovsky at the University of Oxford.

To generate Vincent van Gogh-style pictures, the system consumed only around a few millijoules of energy per image, mostly for the liquid crystal screen, compared with the hundreds or thousands of joules that conventional diffusion models need.

"To put this into perspective, the latter is equivalent to the amount of electricity an electric kettle consumes in a second, whereas the optical machine consumption would correspond to a few millionths of a second," says Lvovsky.

While the system would need to be adapted to work in data centres in place of widely used image-generation tools, Ozcan says it could find a use in wearable electronics, such as AI glasses, because of its low power requirements. ▮

Physics

Miniature engine reveals weirdness of microscopic physics

THE world's hottest engine is tiny, reaches seemingly impossible efficiencies and could approximate nature's smallest machines.

A thermodynamic engine is the simplest machine that can reveal how the laws of physics dictate the transformation of heat into useful work. It has both hot and cold parts, which are connected by a "working fluid" that contracts and expands in cycles. Molly Message and James Millen at King's College London and their colleagues built one of the most extreme engines ever by using a microscopic glass bead in place of the working fluid (*Physical Review Letters*, in press).

They used an electric field to trap and levitate the bead in a small chamber made from metal and glass that was almost entirely devoid of air. To run the engine, they changed the properties of the electric field to tighten or loosen its "grip" on the bead. The few leftover air particles in the chamber acted as the engine's cold part, while controlled spikes in the electric field played the hot part. These spikes made the particle briefly move far more rapidly than the air particles surrounding it. Because hotter particles jiggle faster, the glass particle behaved as if its temperature had momentarily risen to 10 million Kelvin, or around 2000 times the temperature of the sun's surface, though it would have been cool to touch.

During some cycles the engine seemed to be impossibly efficient, with the glass bead moving faster than expected. But during others, the efficiency became negative, as if the bead were cooling down under conditions that should have made it extra hot.

"The engine was so small a single air particle could radically change its functioning"

These oddities could be chalked up to the engine's size: it was so small, even a single air particle randomly hitting the bead could radically change the engine's functioning, says Millen.

Raúl Rica at the University of Granada in Spain says the engine could help researchers understand biological systems more deeply. ▮

Karmela Padavic-Callaghan

Technology

Will Australia's social media ban work?

Social media platforms will soon have to exclude children under 16 in Australia, but there are doubts over whether this is the right approach, finds **James Woodford**

IN JUST a few months, the online world of Australian teenagers will be turned on its head as the federal government's ban on social media for under-16s comes into effect. But with the December deadline looming, children and their parents still have no certainty about how the ban will be enforced.

Many experts are expecting chaos and perverse outcomes, especially as the technology that social media platforms will have to rely on can only assess the ages of young people with significant margins of error.

After 10 December, social media behemoths including Instagram, Facebook, X, Reddit, YouTube, Snapchat and TikTok will have to take "reasonable steps" to remove and delete the social media accounts of all teenagers under 16 in Australia. Failure to do so will result in fines of up to AUS$49.5 million (US$32 million) for corporations. Parents, however, cannot be punished.

Prior to announcing the ban, the Australian government commissioned a trial of age assurance technologies. Interim findings were released in June, with the final report published this week. More than 20 age verification tools were tested on 1100 students from around the continent, including Indigenous and ethnically diverse young people.

Andrew Hammond at the consultancy firm KJR in Canberra, Australia, who led the trial, recounts an anecdote that highlights the scale of the challenge. One 16-year-old boy's age was estimated with four incorrect ages between 19 and 37, he says.

Numerous other technologies were also trialled on other Australian children, including one that depends on hand gestures to age the subject. "It's able to determine how old a person is within a broad range," says Hammond. "It can't tell you if it's your birthday or anything like that, but it can broadly confirm how old someone is just based on their hands."

ANNA BARCLAY/GETTY IMAGES

Major tech companies will be affected by Australia's ban

He says some kids were uncomfortable using their faces for age verification, but they were more comfortable having their hand movements assessed.

The final report determined that while age verification is secure and technically feasible, it isn't possible to assess age without a margin of error. This means that if a person who is initially verified as over 16 is found to be younger, they will have to go through other, more arduous verification methods, such as providing their learner driver's licence, ID, or parental or school confirmation of age.

The report didn't specify a recommended technology for age verification, so each social media platform will need to choose its own methods. Hammond says some underage users would need to be picked up by the social media platforms' algorithms. "If you say that you're 16 and then all of a sudden you're liking all your friends' 11th birthday parties, then it would be up to the social media companies to raise some flags and say, 'Actually, we don't think you're over 16, can you please verify using another method such as an ID?'"

> **"Australia is offering to the world a fantastic opportunity for a controlled experiment"**

Iain Corby at the Age Verification Providers Association in London, who also assisted with the Australian trial, says there is no silver bullet for age verification.

The UK recently introduced mandatory age verification for websites offering "harmful content", including pornography. In the first days after the rules came into effect on 25 July, around 5 million people every day were verifying their age, says Corby.

"In the UK, the requirement was for highly effective age assurance, not perfectly effective age assurance," says Corby. "There is an acknowledgement not only that the technology is never going to be perfect, but also, the closer you get to perfect, the more inconvenient it becomes for adults."

One loophole that is consistently raised by critics is that children in Australia could simply use a virtual private network (VPN) to circumvent the ban by pretending they are in another country.

Corby says social media companies will need to monitor all traffic that comes from a VPN and consider whether that traffic exhibits behaviours that suggest it might be an Australian child. "There will be a bunch of clues to suggest that somebody is not in Thailand, that they are potentially in Perth," he says.

Putting aside the questions over how age verification will work, is a ban on social media use the best way to protect teenagers from the problems they face online? The Australian government has introduced the measure because it says children under 16 need to be protected from the harms associated with social media – including being exposed to adult content and potentially becoming addicted to constant scrolling. The government also says that by delaying access to social media, children can be given more time to become educated about potential harms

Campaigners and charities appear unconvinced. "Social media has a lot of good things, like education and staying in

touch with friends. We think it's more important to make social media platforms safer and to listen to young people to make sure any changes actually help," UNICEF Australia says on its website.

Susan McLean, a leading Australian cybersecurity expert, is among those who say the government should be focusing on the harmful content and the algorithms that put such material in front of children. She is especially critical of AI and gaming platforms having been omitted from the ban.

The world is watching

Lisa Given at RMIT University in Melbourne, Australia, says the ban won't solve the issues of online bullying or accessing inappropriate content. "I think that this is really a false sense of security if parents think the ban is going to protect their kids 100 per cent."

The pace of technological change means that harm will continue to manifest in new platforms and technologies unless inappropriate content is tackled at source, she says. "We're kind of playing a game of Whac-A-Mole because new technologies will pop up and then do we need to have a different ban, or do we need to change legislation?" She is also concerned about young people being cut off from positive online communities and important information.

The government has proposed to review the impact of the ban after two years. Whatever the outcomes, other countries will be watching closely.

"Australia is offering to the world a fantastic opportunity for a controlled experiment," says Corby. "It's a proper science experiment and you don't have this opportunity very often to get a massive sample in a neatly discrete jurisdiction and do this experiment on them." ▮

Health

The foundations of eczema may start to be laid down in the womb

Christa Lesté-Lasserre

STRESS during pregnancy may prime certain immune cells in a fetus's skin to overreact, leading to eczema.

Immune cells called mast cells in the skin release histamine and other chemicals that trigger redness, swelling and itching during allergic reactions. Eczema isn't a type of allergy, but these same chemicals can help fuel the inflammatory flare-ups it induces in response to irritating, rough or damp substances, like soap, washing detergent and diapers.

A series of experiments on mice has now shown that mast cells become hyperreactive when a fetus is exposed to stress hormones in the uterus.

"Making mothers feel guilty is absolutely not the point of this research. Maybe this is more of a message for women's partners and their support systems," says Nicolas Gaudenzio at the Toulouse Institute for Infectious and Inflammatory Diseases in France.

Previous research suggested there is a link between stress during pregnancy and eczema in newborns. To better understand this, Gaudenzio and his colleagues ran experiments on dozens of pregnant mice.

Some were put under stress by being placed in narrow tubes with bright lights shining on them for half an hour, three times a day for five days. The researchers specifically targeted the late second and early third trimesters, a critical window for the development of the immune and nervous systems. The mice's stress hormone levels spiked in both the bloodstream and the amniotic fluid during this period.

"Making mothers feel guilty is absolutely not the point of this research"

After the pups were born, the researchers either mimicked the wearing of diapers by placing pads soaked in saline on their backs or gently rubbed adhesive tape behind their knees and in the bends of their elbows – typical eczema hotspots.

They found that nearly all the offspring of the stressed mothers developed eczema-like rashes that were red, itchy or scaly at those sites, while those born to control mothers – which were free to roam in a cage during pregnancy – sometimes showed mild irritation, but never full-blown lesions (*Nature*, doi.org/g9ztb8).

RNA sequencing of the sensory neurons linking the skin to the spinal cord revealed that nearly 300 genes were expressed differently in the offspring of the stressed mice, many of which are tied to pain, touch and itching, suggesting heightened skin sensitivity.

Sequencing of immune cells from the pups' skin showed 500 differently expressed genes in the mast cells. Under a microscope, these looked as if they were gearing up to release histamine.

The researchers repeated their experiments in pregnant mice treated with drugs that prevent them from creating corticosterone, a hormone that plays an important role in the stress response in rodents, and those pups didn't have eczema. They also gave extra corticosterone to pregnant mice that weren't in stressful situations – their pups did develop eczema.

The team then genetically engineered pups to lack mast cells altogether. Those animals didn't develop eczema, even when their mothers had been stressed.

"It's quite a thorough and very interesting study," says Thomas Plum, who specialises in cellular immunology at the German Cancer Research Center in Heidelberg.

Even so, it is important to keep in mind that the experiments were done on mice. "It's intriguing, but it's just the first foot in the door," says Plum. ▮

Stress during pregnancy can affect the fetus

LIZ HAFALIA/THE SAN FRANCISCO CHRONICLE VIA GETTY IMAGES

Comment

Glow-in-the-dark plants to replace streetlights? Forget it

Michael Le Page

THERE are the bad product ideas that just make you sigh, and then there are the ones you absolutely loathe. For me, glowing plants created by pumping leaves full of phosphorescent chemicals falls firmly in the latter category.

Such plants have been created by researchers from South China Agricultural University, who claim that the plants have "unprecedented brightness" and are a step towards "sustainable, eco-friendly, plant-based lighting systems".

People have been trying to create glowing plants for decades. The challenge is making the glow bright enough for our eyes to see.

Last year, US biotech company Light Bio launched the Firefly Petunia, the first genetically modified glowing plant to go on sale commercially. It claims that the plant's brightness is "similar to moonlight", but judging from photos on social media, we aren't talking a full moon here.

No lightbulb moment

There is a reason why this is so difficult. Plants get their energy from light, but photosynthesis is wildly inefficient. It is estimated that most plants capture less than 2 per cent of the light that falls on them, and they need some of this captured energy to survive and grow. That leaves precious little to convert back into light.

The bottom line is that converting energy captured by photosynthesis into light is never going to deliver trees that can replace streetlights. This inefficiency is probably also why almost all animals steal the energy captured by plants rather than bothering to photosynthesise themselves.

LIU ET AL., MATTER

These plants glow after being injected with phosphor particles

For this reason, a few groups have instead been trying to physically add persistent phosphors to adult plants. We are talking here about the compounds that make things such as stick-on-the-ceiling-stars glow for a while after being exposed to light, a phenomenon known as afterglow luminescence.

Some persistent phosphors are much more efficient than photosynthesis, meaning more light out for the same amount of light put in. The problem is getting the phosphor nanoparticles evenly distributed inside the leaves. But now the researchers in China have found that such distribution is easily achieved in succulents such as *Echeveria* "Mebina", allowing them to create brightly phosphorescent plants of various colours by injecting phosphors into each leaf by hand.

This is little more than a cheap gimmick. Don't get me wrong, I like the idea of genuine glowing plants. I might even buy a Firefly Petunia were they available outside the US. But making plants glow by physically injecting glowing compounds into them is cheating. At the very least, the glow will fade if these plants survive and grow larger. There is also a potential pollution issue when the plants die and are disposed of.

OK, this isn't as unethical as the practice of dyeing aquarium fish, but it is just as tasteless as dyeing roses blue. (No, I am not having an *Alice in Wonderland* moment – you really can buy painted roses.) Nor is there any discussion in the team's paper of the environmental and safety aspects of plants with high levels of phosphors in their leaves. I asked the researchers about this, but had no reply at the time of writing.

If the plants were genetically engineered to make their own persistent phosphors that are fully biodegradable, it would be a different story. In fact, giving plants this ability might even boost the efficiency of photosynthesis. Being able to temporarily "store" light could help even out fluctuations in light levels, convert unusable wavelengths into useable ones and allow photosynthesis to continue into the night. One day, perhaps entire fields will glow in the dark.

In the meantime, I hope fake glowing plants created by injecting phosphors never reach shop shelves – but I rather fear they shall. ▮

Michael Le Page is an environment reporter at *New Scientist*

Health

Surgery may be best solution for chronic sinus condition

Carissa Wong

PEOPLE with a chronically blocked or runny nose often take antibiotics, but surgery could be better.

Chronic sinusitis affects about 9 per cent of people worldwide and occurs when the mucus-producing cavities – sinuses – around the nose become inflamed.

The first line of treatment involves anti-inflammatory nasal sprays and flushing saline solution through the nose. If symptoms persist, doctors can prescribe a three-month course of the antibiotic clarithromycin.

As a last resort, people can undergo surgery to widen the sinuses and remove any benign nasal growths, or polyps, which form and can worsen symptoms.

To compare surgery with antibiotics, Carl Philpott at the University of East Anglia in the UK and his colleagues recruited more than 500 adults with chronic sinusitis. In surveys, the participants rated the severity of 22 symptoms, such as facial pain and how runny their nose was, with an average score of 55 out of 110.

The team then randomly assigned the participants to take either a three-month course of clarithromycin or placebo pills, or undergo nasal surgery. All the participants also used nasal sprays and rinsed their noses with saline.

Six months later, the surgery group saw a roughly 30-point improvement in their symptoms, compared with around 10 points in the other groups (*The Lancet*, doi.org/p363).

However, about 80 per cent of participants had nasal polyps, perhaps because the study took place during the covid-19 pandemic, and the coronavirus may lead to polyps, says team member Claire Hopkins at King's College London. Further studies are needed to check whether the results apply to those without polyps, who have different types of inflammation, she says. ▮

Climate

French Revolution's volcanic origins

Social upheaval across Europe between 1250 and 1860 coincides with extreme weather

James Woodford

SEVERE volcanic eruptions and changes in the activity of the sun may have set the scene for the French Revolution.

It has long been known that tough environmental conditions can lead to social chaos.

One of the most severe periods of weather experienced over the past millennia, known as the Little Ice Age, gripped parts of the northern hemisphere, especially Europe and North America, from about 1250 to 1860. During this period, temperatures dropped by an average of up to 3.15°C (1.75°F).

David Kaniewski at the University of Toulouse in France and his colleagues scoured the literature to find 140 rebellions during this interval that were large enough to register in the historical record.

They compared the records of these various social crises with those of solar activity, volcanic eruptions and climate change, along with swings in the price of grain and bread, to see if there was any connection between them and extreme weather associated with the Little Ice Age.

They found that particularly cold phases of the Little Ice Age correlated with significant increases in rebellions.

"We also found that major volcanic eruptions, which temporarily cool the climate, were followed by social chaos at levels that were statistically significant," says Kaniewski.

When temperatures fell by between 0.6°C and 0.7°C, whether through volcanic activity or a decrease in the number of sunspots, there was an increase to 0.72 rebellions per year on average.

But the team found the strongest correlation when comparing the number of rebellions or revolutions with the price of wheat and barley. Steep price rises led to an increase to 1.16 rebellions per year (*Global and Planetary Change*, doi.org/p37g).

However, they also found that some nations, such as England, which also experienced weather turmoil during this period, adapted better than others.

The researchers think that while climate didn't directly lead to rebellion, environmental conditions led to cascades of events that led to food shortages, evidenced in increasing grain prices. This, in turn, could encourage people to revolt.

One of the most extreme periods of upheaval followed the eruption of Iceland's Laki volcano in June 1783, which led to higher levels of sulphur dioxide in the atmosphere and had a cooling effect on the climate. The team discovered that following this period, from 1788 to 1798, there was a peak of 1.4 rebellions annually, including the tumult of the French Revolution.

Kaniewski says understanding the Little Ice Age may offer a glimpse into the challenges facing humanity with future climate predictions: "Today's climate change could be far more disruptive."

"Understanding this period may offer a glimpse into the challenges facing humanity in the future"

Tim Flannery at the Australian Museum in Sydney, however, says the link between climate change and rebellion, as demonstrated in this study, is a matter of correlation, not cause.

"It's just as likely that people will fall into chaos, migrate, commit suicide or whatever else during a stressful period, as start a revolt," says Flannery. ▮

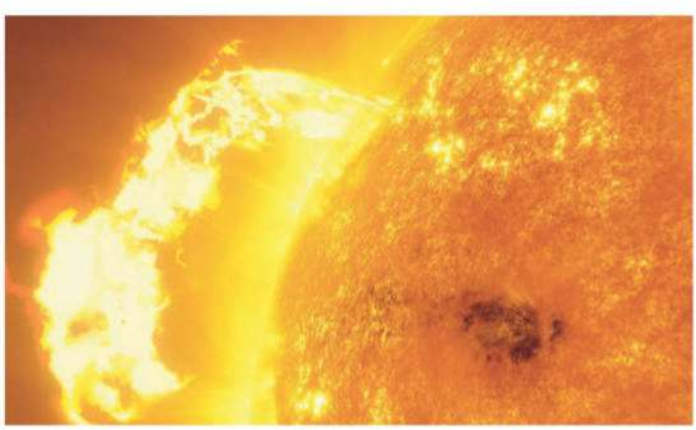
Space

Probes could help warn us of solar storms far sooner

WE MAY one day be able to forecast powerful solar storms capable of devastating Earth's electronics more than half a day in advance.

The sun occasionally releases powerful blasts of plasma called coronal mass ejections (CMEs), which can generate strong magnetic fields that damage electronics here on Earth. However, we can't accurately predict which ejections pose a threat, as this depends on the magnetic field inside the CMEs themselves.

Among our most reliable tools for measuring these magnetic fields are satellites in gravitationally stable orbits around Earth called Lagrange points. These satellites are hundreds of thousands of kilometres from Earth – but they are still positioned only about 1 per cent of the distance between our planet and the sun, which helps explain why they can only give less than an hour's warning of how strong a CME might be.



MARK GARLICK/SPL/ALAMY

Coronal mass ejections from the sun can disrupt electronics on Earth

Now, Emma Davies at the Austrian Space Weather Office in Graz and her colleagues have found a way to provide an earlier warning using the European Space Agency's Solar Orbiter, which orbits our star at 30 to 90 per cent of the distance between the sun and Earth.

On 17 and 23 March this year, Solar Orbiter was passing between Earth and the sun when two pairs of CMEs began racing towards our planet. Davies and her team used the spacecraft's measurements of the magnetic field and solar wind speed to model each CME's internal magnetic structures. They then used these to predict the strength of the geomagnetic storms each CME would produce 7 and 15 hours before they reached Earth, respectively (arXiv, doi.org/p4f3).

However, Davies says the storms were still hard to predict accurately, with several hours of uncertainty. ▮

Alex Wilkins

Health

We may know why psilocybin helps treat mental health conditions

Chris Simms

A SINGLE dose of the psychedelic compound psilocybin could be enough to remodel connections in specific brain networks, which may explain how the drug helps treat some mental health conditions.

Psychedelic drugs such as psilocybin, which is produced in hundreds of species of magic mushroom, have shown promise in the treatment of mental health conditions like depression and anxiety. It is suspected that this is through psilocybin increasing the brain's plasticity – its ability to change its connections – but how it does this hasn't been clear.

Now, Alex Kwan at Cornell University in Ithaca, New York, and his colleagues have run a series of experiments in which they injected mice with either a dose of psilocybin or saline solution. A day later, they injected a genetically modified version of the rabies virus. This virus can jump across synapses, the gaps between neurons, so it can be used to show which neurons connect to the region where the virus was originally injected.

The researchers visualised the brain-wide effects of the virus using scans and dissections to reveal which neurons had made new connections. From this, they could show that the mice given a dose of psilocybin had strengthened connections between the retrosplenial cortex – which is associated with imagination, memory and integrating sensory information – and the prefrontal areas – which are involved in planning and social behaviour – when compared with the mice given saline solution (bioRxiv, doi.org/p37m).

Psilocybin also seems to decrease connections that are part of recurrent loops in the cortex. These loops allow important memories to be retained for longer, but in some mental health conditions they can lead to a persistent focus on negative thoughts or behaviours. Breaking cycles of rumination by weakening these loops has been hypothesised as a key part of the process for treating many mental health conditions.

"Mice given a dose of the drug had strengthened connections between specific brain networks"

"I think it's the next step in what we need to uncover," says Michael Wheeler at Brigham and Women's Hospital in Boston. "Those types of circuits underlying the connections between these associative areas could be potentially a key to unlocking their mechanisms."

"The way the brain gets remodelled by psilocybin treatment is critical for its effects on mood disorders," says Eero Castrén at the University of Helsinki in Finland. It is important to note, however, that psilocybin is only enabling the remodelling, he says. Which circuits are actually strengthened or weakened may depend on what an animal is doing and sensing.

The work suggests it will one day be possible to choose which brain connections to remodel, depending on the mental health condition that is being treated. "Our study hints at an exciting avenue for future research to combine neuromodulation with psychedelics to precisely target specific circuits for neural plasticity," the researchers write. ▮

Space

SpaceX's Starship finally completes successful test flight

THE world's most powerful rocket, SpaceX's Starship, has completed a successful suborbital test flight after a run of three disappointing launches that ended in fiery explosions.

SpaceX is several years into its development programme for Starship, intended to be a rapidly reusable and extremely powerful launch vehicle that will take over the rollout of the company's Starlink satellites and be a central part of NASA's Artemis moon missions.

Test flights 7, 8 and 9 all ended in disaster for Starship's upper stage, which either exploded or broke up on reentry and didn't reach Earth for a safe landing. Preparations for test flight 10 also encountered problems when an upper stage exploded while it was being loaded with propellant for a ground test.

UPI/ALAMY

Starship launches from SpaceX's Starbase in Texas for its 10th test flight

But the 10th test flight on 26 August from SpaceX's Starbase in Texas was largely a success, albeit one that came after two consecutive launch date cancellations.

The upper stage reached space, deployed eight mock-up Starlink satellites and tested its ability to relight its engines in a vacuum. An unexpected explosion did cause damage near the engines, but the ship completed its mission, reentered Earth's atmosphere and slowed itself for a controlled splashdown in the Indian Ocean, where a camera-equipped buoy gave SpaceX engineers views of the craft's behaviour.

The booster stage separated from Starship and also carried out a controlled splashdown, this time in the Gulf of Mexico.

SpaceX didn't respond to a request for comment, but said on its website that every "major objective was met" during the mission. However, doubts remain that the craft can be ready for NASA's Artemis III crewed moon landing, scheduled for 2027. SpaceX also still aims to send a Starship – albeit uncrewed – to Mars in 2026. ▮

Matthew Sparkes

Advertorial paid for by Alzheimer's Society

Revolutionising dementia diagnosis

Emerging blood biomarkers promise earlier, more accurate diagnosis, transforming patient outcomes nationwide

Right now, the way people are diagnosed with dementia in the UK is not good enough. Current figures estimate that more than a third of people over 65 who are living with dementia in England are undiagnosed. Waiting times for diagnosis are also on the rise, with people waiting an average of 22 weeks from referral to diagnosis.

There are now treatments on the horizon that slow the progression of Alzheimer's that are most effective earlier in the disease – so getting an early and accurate diagnosis is more important than ever.

In April 2023, Alzheimer's Society and Alzheimer's Research UK, thanks to players of People's Postcode Lottery, jointly launched the game-changing Blood Biomarker Challenge, which is gathering the information needed to introduce a blood test for dementia into UK healthcare systems.

A blood biomarker is an indicator that can be measured in the blood, that can show if a person has a disease or has early warning signs of a disease and may be at risk of developing it.

"There are now treatments on the horizon that slow the progression of Alzheimer's"

In Alzheimer's disease, there is an abnormal build-up of proteins in the brain, which are thought to be toxic to brain cells and lead to the symptoms that affect people with dementia. These proteins include amyloid and tau.

Protein build up

When proteins build up in the brain, the body tries to clear them away. As a result, these proteins can cross into a spinal fluid surrounding the brain and spinal cord. Researchers have found these proteins can also leak through into the blood and be detected using a blood test.

In the future, we believe doctors will be able to use blood tests to indicate whether an individual has a buildup of these proteins in their brain. This, alongside other tests and clinical observations, will support doctors to make an earlier and more accurate diagnosis of Alzheimer's disease.

Blood-based biomarkers could be the cost-effective, accurate and non-invasive diagnostic tool that is needed to revolutionise dementia diagnosis in the NHS.

Find out more about the Blood Biomarker Challenge at alzheimers.org.uk/bbmc

DEMENTIA IS THE UK'S BIGGEST KILLER...

At Alzheimer's Society, we know the steps it will take to create a future where dementia no longer devastates lives. Only together can we beat dementia – by giving vital support to those who need it; funding groundbreaking research; and campaigning to make dementia the priority it should be. It will take a society to beat dementia.

Alzheimer's Society

It will take a society to beat dementia

Palaeontology

Ancient croc may have dined on dinosaurs

James Woodford

JOSÉ BRUSCO, CC-BY 4.0

A reconstructed skeleton of *Kostensuchus atrox*, which was more than 3 metres long

A CROCODILE relative that lived around 70 million years ago was probably such a formidable predator that it could have eaten medium-sized dinosaurs for breakfast.

"Its large teeth had serrated edges like steak knives, which is a strong signal that this animal could tear through muscle and bone, probably hunting small-to-medium-sized dinosaurs or other large prey," says Diego Pol at the National Council for Scientific and Technical Research in Buenos Aires, Argentina.

Kostensuchus atrox, which in life would have been about 3.5 metres long and weighed around 250 kilograms, was found in March 2020 in southern Patagonia. The fossil included a beautifully preserved skull and parts of the predator's skeleton (*PLOS One*, doi.org/g9znbc).

Its genus name comes from the Patagonian wind known as the kosten and the Egyptian crocodile-headed god known as Souchos, with *atrox* meaning fierce or harsh in Greek.

It lived at the end of the Cretaceous and is from a group of crocodile relatives known as the peirosaurid crocodyliforms, which didn't survive the extinction event 66 million years ago that also wiped out most dinosaurs.

Unlike modern crocodiles, which have long, flat snouts, *Kostensuchus* had a high, wide and extremely robust skull built for sheer power, says Pol. Its limbs were more elongated than those of modern crocodiles, suggesting it was capable of more agile movement on land.

"Their body proportions and skull shape suggest they could move better on land and may have hunted on land too," he says.

Another indication of this is that its nostrils were located at the front of the snout, not on top of the skull, which means it wouldn't have been able to breathe and keep most of its body submerged at the same time.

It had more than 50 sharp, serrated teeth, some more than 5 centimetres long. Pol says these teeth weren't just for gripping, but also for slicing through muscle.

"These traits helped us place it as a top predator, coexisting with large meat-eating dinosaurs," he says.

Health

Urine tests can effectively detect high-risk HPV

Elizabeth Hlavinka

URINE tests seem to detect strains of the human papillomavirus (HPV) that are particularly associated with cervical cancer with the same level of accuracy as vaginal swabs that people carry out themselves.

Cervical cancer screening has historically been performed by a medical professional collecting cell samples from the cervix, either to test for abnormal cells or for the presence of HPV strains that are responsible for most cases, like HPV 16 and 18.

In countries like the US and Canada, people now have the option of using self-collected vaginal swabs, which don't need to touch the cervix. The UK is also moving towards this approach. Such swabs have been linked to increased screening uptake, but still may be uncomfortable for some.

Previous research suggests the DNA of HPV can be detected in urine. To better understand its potential, Julia Lynch at the International Vaccine Institute in Seoul, South Korea, and her colleagues asked 753 sexually active women, aged 18 to 25,

KATERYNA KON/SPL/ALAMY

Certain strains of HPV are associated with cervical cancer

to collect a urine sample at any time of day and to carry out a vaginal swab while in a clinical setting in Bangladesh, Pakistan or Nepal.

They found that the tests' ability to detect seven high-risk HPV strains was highly similar for both sample types, with 5.3 per cent of the self-collected swabs positive for one or more of the seven strains, compared with 5 per cent for the urine sample. For HPV 16 and 18, the results were nearly identical, at 2.3 per cent for the swabs and 2.4 per cent for the urine test (medRxiv, doi.org/p35s).

Urine samples also seemed to be preferred by some. "We are working in countries with a lot of different social contexts, and [a] vaginal swab was less acceptable for some ages in some countries," says Lynch.

The World Health Organization set a goal to eliminate cervical cancer in 2018, based largely on the success of HPV vaccines. But it can take years for the effects of vaccine initiatives to be seen at the population level, so screening uptake is still needed, says Lynch.

> "The tests' ability to detect seven high-risk strains was similar to self-collected swabs"

There are several types of HPV vaccines, which all protect against strains 16 and 18. But HPV risk is typically based on data from North America and Europe, says Lynch, so studies like this may also help determine which strains are circulating in other parts of the world.

The study included only young women, so the findings may not be generalisable to everyone, says Beverly Green at Kaiser Permanente Washington Health Research Institute. Lynch says the study was part of a larger project to determine HPV prevalence among eight low- and middle-income countries in South Asia and Africa. Other studies within this project will test samples from older women.

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Microbiology

Unlocking microbes' survival secrets

Frozen microorganisms alive for over 100,000 years offer clues to achieving extreme lifespans

James Dinneen

MICROBES isolated from Siberian permafrost appear to have stayed alive for more than 100,000 years, based on an analysis of their DNA. Their genetic overlap with other, more complex species could yield insights into how prevalent such long lifespans are, and how they have come to evolve.

Microbes found elsewhere have been isolated from extremely ancient marine sediments – some more than 100 million years old – but it remains unclear whether individual organisms can survive over those stretches of time.

Karen Lloyd at the University of Southern California and her colleagues wanted to find microbes in places they knew hadn't changed for very long periods of time, reasoning anything still living there must be as old as the surrounding environment. That search took them to the Chukchi peninsula at the easternmost edge of Siberia, where they drilled a 22-metre-long core of permafrost.

This let them sample DNA from a layer of marine sediment that froze sometime between 100,000 and 120,000 years ago. The sediment contained pores of liquid water where microbes might have been trapped, with no nutrients or organisms able to move in or out.

To distinguish between living and dead cells, the researchers sequenced millions of DNA fragments from the permafrost, using them to reconstruct the genomes of all the microbial species present. They then added an enzyme to the mix that would repair degraded DNA and repeated the reconstruction process.

Most of the reconstructed genomes were much more complete after the researchers added the DNA repair enzyme, suggesting they came from dead cells that hadn't been actively maintaining their DNA's integrity, says Lloyd. However, genomes from six species barely changed, implying the DNA came from living cells that had actively maintained their genomes since being frozen at least 100,000 years earlier (Biorxiv, doi.org/p328).

> "This research is a real advance towards understanding extremely long lifespans"

All six species with intact DNA came from the phylum Promethearchaeota, also known as the Asgard archaea. These organisms are considered the closest living relative of all eukaryotes – the domain of life that includes animals, plants, fungi and protists.

A further surprise was that the long-lived species weren't appreciably different from Asgard archaea isolated in less-restricted environments. All of them shared similar genes for protein and DNA repair, which may have enabled them to slowly replace parts of their cells – without dividing – while in extremely low-energy environments.

Steven D'Hondt at the University of Rhode Island says the research is a "real advance" towards understanding extremely long lifespans – both how widespread they might be and the evolutionary basis for them.

However, he cautions against applying these findings to other settings. "Being frozen for a long time with no activity is not the same thing as living for a long time with a very low level of activity." ▮

Marine biology

Long-lost shark recorded for the first time in decades

ONE of the rarest sharks in the world has turned up in Papua New Guinea, some 50 years after it was last reported.

Adorned with a curiously large and deep dorsal fin, the sailback houndshark (*Gogolia filewoodi*) was first described by scientists in 1973, when a pregnant female shark was caught in Papua New Guinea's Astrolabe Bay, near the Gogol river. This single animal remained the only record of the species for decades.

Jack Sagumai at the World Wildlife Fund-Pacific in Papua New Guinea and his colleagues were gathering fisheries data directly from local communities as part of a project supporting the country's National Plan of Action on Sharks and Rays. In March 2020, they received quite the surprise: photographs of multiple small sharks caught near the mouth of the Gogol river, all under a meter long and with a pronounced dorsal fin.

In total, there were five such sharks, later determined to be females. In 2022, another fisher found a male nearby. With the help of William White at the Commonwealth Scientific and Industrial Research Organisation in Australia, the team confirmed these fish were long-lost sailback houndsharks (*Journal of Fish Biology*, doi.org/p33g).

JACK SAGUMAI ET AL. (2025)

After pulling a 50-year vanishing act, the sailback houndshark has re-emerged

Although the finding represents the first scientific record of the shark in more than 50 years, fishers in Astrolabe Bay do report occasionally encountering these sharks. They mostly find sailback houndsharks around the mouth of the Gogol river when fishing for drum, says Sagumai.

Details on the sailback houndshark's biology and population size are still lacking, says Sagumai. But two deceased specimens are now kept at the University of Papua New Guinea, and the team plans to collaborate with researchers in Australia and Florida to analyze the sharks' DNA. ▮

Jake Buehler

Health

Heatwaves may make you age faster

Jeremy Hsu

SPENCER PLATT/GETTY IMAGES

ACCUMULATED exposure to hot-weather days appears to accelerate people's biological ageing.

"We now have at least two prominent studies showing an impact of heatwave exposure on ageing, with these examining populations from two different countries," says Paul Beggs at Macquarie University in Australia.

Siyi Chen at the University of Hong Kong and her colleagues used medical screening data from nearly 25,000 adults in Taiwan to determine the biological age of each person based on inflammation, blood pressure, organ function and more. Next, they compared each individual's biological age with their chronological age, to figure out if they were ageing faster or slower than normal.

The team then calculated each person's cumulative exposure to heatwaves – including the total number of heatwaves they had lived through – up until two years prior to their medical screening. The total number of heatwave days experienced ended up being the most significant factor for accelerated ageing (*Nature Climate Change*, doi.org/p33c). The results

Hot weather can have many negative health effects

aligned with a recent study that investigated outdoor heat's impact on ageing in older US adults.

For the Taiwanese group, the ageing effect generally increased as the amount of cumulative heatwave exposure did. Each four-day increase in total heatwave duration was associated with a biological age increase equivalent to about nine days.

But the effect was even more pronounced for specific groups of people. For instance, manual workers experienced around three times as much accelerated ageing from the same amount of heat exposure compared to the group as a whole. Residents of rural communities also experienced greater ageing impacts, indicating access to air conditioners might be able to stave off heat's ageing effects, the researchers say.

To avoid making climate change and heatwaves worse, however, air conditioning will need to be complemented by more sustainable cooling solutions, says Beggs. ▮

Genetics

Fresh hints about why thylacines went extinct

James Woodford

THE loss of crucial genes over millions of years before the arrival of humans in Australia may have left thylacines more vulnerable to extinction.

The thylacine, or Tasmanian tiger (*Thylacinus cynocephalus*) was the last survivor of a family of marsupials known as Thylacinidae that lived across Australia and New Guinea.

By 2000 years ago, the animals were extinct on the Australian mainland, with hunting by humans and competition from dingoes thought to be major reasons for their decline. After Europeans arrived in Tasmania, thylacines were persecuted by farmers and a government bounty. The last one died in Hobart Zoo in 1936.

Nagarjun Vijay and Buddhabhushan Girish Salve at the Indian Institute of Science Education and Research Bhopal became interested in the genome

"We thought we might see some genes that were lost and linked to disease, and we did"

of the Tasmanian tiger while studying the genome of the Bengal tiger (*Panthera tigris tigris*).

The pair suspected that hypercarnivores like the Bengal tiger and the Tasmanian tiger have, through their evolutionary history, lost genes that may leave them vulnerable when exposed to environmental changes or new diseases.

They analysed genetic records previously recovered from thylacine museum specimens and compared them with the genome of their close relative, the Tasmanian devil (*Sarcophilus harrisii*), and other marsupials.

In contrast to almost every other marsupial, including Tasmanian devils, thylacines had lost at least four important genes, known as *SAMD9L*, *HSD17B13*, *CUZD1* and *VWA7* (*Proceedings of the Royal Society B*, doi.org/p327).

Vijay says they were surprised to discover that the loss of the genes seemed to have occurred before the Tasmanian population became isolated, when sea levels began to rise about 10,000 years ago.

The loss of these genes might have had advantages in the past, but it potentially compromised the species' health by reducing antiviral defences, metabolic processes, lactation and their susceptibility to cancer and pancreatitis, Vijay and Salve suggest.

Thylacines lost *SAMD9L*, *CUZD1* and *VWA7* at least 6 million years ago, at a time of massive climate change – a period that saw the species increase dramatically in size and become a hypercarnivore.

"The overall narrative has always been that it is mostly human intervention, or anthropogenic changes, that have had an effect on the extinction of thylacines," says Vijay. "And we were thinking, maybe we will see some genes that were lost that are linked to disease. And that is what we found."

Timothy Churchill at the University of New South Wales, Sydney, says there is no doubt climatic changes led to a dramatic loss of thylacines' genetic diversity. He says it is also possible that the gene losses reported in the new study could have made Tasmanian tigers more susceptible to disease, but confirming this would require much more research. ▮

Environment

Only half of calories produced actually reach people's plates

Michael Le Page

CHAIDEER MAHYUDDIN/AFP VIA GETTY IMAGES

The use of palm oil for biodiesel is one factor affecting the food system

THE world produced enough calories in 2020 to feed 15 billion people – but only 50 per cent of those calories were available for people to eat. This proportion is now very likely to have fallen even lower because of the declining efficiency of the global food system.

Rising production of meat – especially beef – and biofuels such as ethanol and biodiesel are the main reasons for this increasing inefficiency, according to Paul West at the University of Minnesota and his colleagues. Shifting to healthier diets and reducing biofuel production could increase food availability without requiring more farmland.

Food production is typically measured in terms of mass, but looking at it in terms of calories – the amount of energy in the food – is more informative when it comes to comparing different crops and assessing how much people need.

To do this, West's team started with data from the UN Food and Agriculture Organization on the top 50 crops in terms of calories. These together provide 97.5 per cent of all the calories grown around the world. They include staples such as maize, oil crops like sunflower, cacao and some fruits and vegetables, including bananas and tomatoes.

Next, the team used data on how efficiently animals convert feed into meat, milk or eggs to work out how many calories are lost during the production of animal-based foods. To eliminate short-term trends, the team's figures for 2010 and 2020 are the average over three years.

15bn

The number of people who could have been fed on food produced in 2020

They found the total global calorie production increased by around 24 per cent between 2010 and 2020. However, the number of calories available for people to eat increased by only 17 per cent.

This is because not only are more calories being fed to animals, they are being fed to livestock such as beef cattle, which are less efficient at converting feed into meat compared with, for example, chickens. Altogether, 45 per cent of the calories grown in 2020 were lost during the production of animal-based foods. Simply switching from beef to chicken would reduce the number of calories lost.

Another 5 per cent of calories produced during 2020 were used for making biodiesel and bioethanol. Specifically, the use of palm oil calories for biodiesel increased by 34 per cent (EarthArXiv, doi.org/p326).

The study doesn't account for food waste, which results in further lost calories. What the study reveals is not all food waste is equal – reducing waste of animal products like beef matters most because so many calories go into producing it.

"It is an important reminder that the problems we face in feeding 8 billion people today – and even in the future with a few billion more – are not about biophysical limits; it's not that we can't produce enough calories," says Hannah Ritchie at the University of Oxford, who was not involved in the study. "It's about distribution and human choices on what we do with them."

Calories aren't everything, though, Ritchie notes. Proteins and micronutrients are also crucial. She hopes the team will extend its work to look at these.

New Scientist contacted West, but he declined to discuss the work ahead of publication in a peer-reviewed journal. ▮

Space

Astronaut CPR device could help resuscitate in space

Matthew Sparkes

MICROGRAVITY makes many simple tasks tricky, so it is no wonder that performing CPR in space is a very demanding procedure. But machines could do the job more effectively.

NASA's CPR protocol for the International Space Station is to wedge yourself and the patient between two hard surfaces, do a handstand on their chest and push with your legs to provide compression.

To find a better way, Nathan Reynette at the University of Lorraine in France and his colleagues tested various CPR methods in an Airbus A310 aeroplane flying parabolic curves, a manoeuvre that creates 22 seconds of microgravity. They also tested three chest compression machines used in cramped environments on Earth, such as in air ambulance helicopters.

All the methods were applied to a training dummy and the depths of chest compression achieved were carefully monitored. The European Resuscitation Council says a depth of at least 50 millimetres is necessary to be effective: the best mechanical device achieved 53 millimetres, while the handstand method achieved 34.5 millimetres.

The research was presented at the European Society of Cardiology Congress in Madrid on 31 August.

As space travel becomes more common and astronauts aren't all extremely fit people, the likelihood of cardiac incidents in orbit will grow larger, says Aaron Parkhurst at University College London.

A NASA spokesperson said in a statement: "NASA has not conducted dedicated studies on the use of CPR machines in microgravity; however, our medical team closely follows all emerging research and findings and will continue to do so as the agency prepares for future human exploration missions to the Moon, Mars, and beyond." ▮

Technology

Broken gadget? Simply dissolve it

3D-printed devices that break up in water could make electronics more sustainable

Jeremy Hsu

ELECTRONICS such as Bluetooth speakers can be 3D-printed from a material that dissolves in water within hours. That allows designers to rapidly create prototypes, enables easier recycling of the resulting electronic waste, and may even inspire more sustainable versions of mass-manufactured consumer electronics.

Researchers demonstrated the dissolvable technology in printed circuit boards, which contain the crucial components and wiring of modern electronics. Hundreds of millions of printed circuit boards are manufactured every year for military fighter jets, cars, medical devices, smartphones and cheap toys. But the world recycles just a fraction of these devices in a "very brute-force way", by shredding them to extract reusable materials, says Huaishu Peng at the University of Maryland.

Peng and his colleagues designed 3D-printable circuit boards using polyvinyl alcohol, a polymer that can dissolve in water. To form the wiring, they injected a gallium-indium metal alloy into the circuit board's channels in liquid form. They then manually placed electronic components on the board. Additional polymer glue was applied to seal the circuits before drying the device for an hour at 60°C.

"Dissolvable circuit boards could be very useful when designers are testing electronics prototypes"

Using these boards, the researchers assembled working versions of a Bluetooth speaker, a fidget toy and an electronic three-finger gripper. A little splash of water won't instantaneously destroy such devices – but after 36 hours in room-temperature 22°C water, the machines did dissolve.

Then the researchers easily picked out the electronic components and most of the liquid metal, which had broken up into small beads. Once they evaporated the water, they were also able to recover 99 per cent of the dissolved polyvinyl alcohol (*ACM Symposium on User Interface Software and Technology*, DOI: 10.1145/3746059.3747604).

Such dissolvable circuit boards could be very useful when designers are rapidly building and testing electronics prototypes, because it is usually difficult to recycle printed circuit boards, says Jasmine Lu at the University of Chicago in Illinois, who has done related research on reusing circuit board materials.

A 2022 United Nations report showed Asia generated 600,000 tonnes of used circuit boards while recycling just 17 per cent of this type of e-waste. Europe and North America generated 300,000 tonnes of printed circuit boards apiece, with Europe managing to recycle 61 per cent of this e-waste and North America 44 per cent.

The fact anyone with a 3D printer can adopt this dissolvable electronics approach makes it especially unique when compared to other sustainable electronics efforts, says Lu. During use, the devices could be further protected with temporary waterproof cases, Peng suggests.

But the limited durability of the circuit boards currently makes the dissolvable electronics better suited for the rapid prototyping of designs, rather than the mass manufacture of finished electronics products, says Lu.

Peng and his colleagues are contacting circuit board producers to explore how mass manufacturing might work. ▮

Palaeontology

Dinosaur's bizarre spikes were fused to its skeleton

A DINOSAUR fossil found in Morocco may be the most bizarrely and elaborately armoured vertebrate that has ever walked the planet.

The first fossil of *Spicomellus afer* was discovered in Morocco and reported in 2021. It was only a rib fragment with fused spikes, suggesting that it belonged to a group of dinosaurs known as ankylosaurs. These short-limbed, wide-bodied herbivorous dinosaurs are characterised by their covering of plates and spines.

Then, in October 2022, a farmer in the badlands of Morocco's Middle Atlas mountains began to excavate a much more complete *Spicomellus* skeleton. That fossil has now been dated to 165 million years ago, in the Jurassic Period. The creature was probably about 4 metres long and weighed up to 2 tonnes.

Armoured dinosaurs such as stegosaurs and ankylosaurs, like modern crocodiles, had bony plates that sat in the skin called osteoderms. But in the *Spicomellus* fossil, there are two different types of bony armour: osteoderms and spikes that are actually fused to the bone (*Nature*, doi.org/p35j).

THE TRUSTEES OF THE NATURAL HISTORY MUSEUM, LONDON

A *Spicomellus afer* fossil which was uncovered during a dig in Morocco

"It's unheard of among armoured dinosaurs, and indeed anything that has osteoderms, which is totally crazy," says Susannah Maidment at the Natural History Museum in London, a member of the team that analysed the fossil. The creature was so bizarre, Maidment says she "ran out of hyperboles to describe it."

In total, the *Spicomellus* specimen has dozens of armoured spikes covering almost its entire body. Some spikes attached to a neck collar are nearly a metre in length. There are also fused vertebrae in the tail, indicating that it may have been a fierce weapon.

The armour is so complex that the researchers think it may also have been used to attract mates. ▮

James Woodford

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Views

The columnist Chanda Prescod-Weinstein grapples with space-time p22

Aperture Birds from around the world take centre stage p24

Culture A psychoanalyst's captivating memoir about love p26

Culture columnist Emily H. Wilson on William Gibson's *Neuromancer* p28

Letters Thoughts on being an independent 'otrovert' p29

Comment

Looking ahead

Societies can be united and inspired by ideas of the future. We urgently need more of them, argues futurist **Sarah Housley**

THE 20th century was a famously fertile time for visions of the future, but the 21st century has failed to inspire them in the same way. Science fiction writer William Gibson, author of the prescient cyberpunk novel *Neuromancer* (see page 28), has called this "future fatigue", pointing out that we barely ever make reference to the 22nd century.

One reason for this apparent stasis is that most of the ideas of the future that captured people's imaginations in the 20th century have mutated since then. For example, plastic was billed as the material of the future. It has become an abundant material resource that is durable and versatile, just as its manufacturers promised. But as it turns out, these properties have made our use of plastic a major problem, for the environment and for our health.

The dominant images of the future that we are presented with at the moment all have long histories to them. They include space colonisation, dystopian artificial intelligence and a longing to bring back the past – but a past that never was. This makes sense given the climate anxiety and dread about the future felt by many people. The future has started to feel like it is closing off rather than opening out.

Jean-Louis Missika, a former deputy mayor of Paris, has written that "when the future is dark, people turn to an idealised past, a lost golden age. Nostalgia becomes a refuge against dangers, a cocoon against the announced declines."

SIMONE ROTELLA

Another reason for our "stuck" images of the future is that social media feeds present users with endless images, all at once, from a wide mix of time periods. This encourages nostalgia and facilitates a constant remix of existing ideas.

It's not that absolutely no new future visions have emerged this century – think of solarpunk, for instance, a movement based on climate hope that developed online in the 2000s on Tumblr and on blogs. But it is notable that no major, forward-looking future visions have taken root in our collective imagination since smartphones came to dominate our way of communicating.

I think about the future for a living and it is my experience that cohesive visions of desirable futures can inspire people to bring about change. They act as motivators and imagination engines. We can use them to visualise the society we want and then commit to work towards that future. Civil rights movements have long understood this. Unifying visions of the future are also effectively used in architectural renderings, ads and TV shows; *Star Trek* has inspired technologists for decades.

We are living through a time of transition, as we move from fossil fuels to renewables. This can feel terrifying, but can also be galvanising. There are plenty of hotspots of innovation today: look at the rise of rooftop solar energy in Pakistan, where households and small businesses are energetically embarking on the shift to renewables, or the communities around the world participating in Transition Towns by rethinking how their local economies and cultures can work.

But we lack synthesis: future thinking that assembles these innovations together into cohesive visions, puts them in a social context and then scaffolds from the present into the future.

In my new book, I look at four future visions being developed today: more-than-human futures reimagines our relationship with nature; degrowth redesigns the role of the economy; solarpunk recharges cultural innovation; and the metaverse immerses us in vivid digital worlds.

But the future doesn't stop with these – there should be many more visions emerging. We need to seed them, grow them and see what shape they take when we tell stories of the future once again. ▮

Sarah Housley is the author of *Designing Hope: Visions to shape our future*

Field notes from space-time

What's in a hyphen? Seeking endorsements for her new book, Chanda Prescod-Weinstein recently found herself staring at fundamental questions of space, time and grammar

Chanda Prescod-Weinstein is an associate professor of physics and astronomy at the University of New Hampshire. She is the author of *The Disordered Cosmos* and the forthcoming book *The Edge of Space-Time: Particles, poetry, and the cosmic dream boogie*

Chanda's week

What I'm reading
I'm super hyped about the new Charlie Jane Anders novel, Lessons in Magic and Disaster.

What I'm watching
I just caught up on the sci-fi series Invasion, *and it's really interesting.*

What I'm working on
I'm onboarding a new postdoctoral researcher into my group.

This column appears monthly. Up next week: Graham Lawton

ONE of the most awkward parts of writing a book is that, eventually, authors have to ask people for "blurbs" – the endorsements that you see on the cover of a book, encouraging you to buy it. I am now in this phase with *The Edge of Space-Time*. I'm writing to people and asking them to read my book and send me some nice words about it, in exchange for nothing but my goodwill.

It's a bit nerve-wracking, but it can also be interesting. One person – whose endorsement will become public later – sent in their blurb with a query: why did I choose "space-time" with a hyphen rather than "spacetime"?

This sounds like it's "just grammar", but something else is lurking. When we talk about space or time separately, we have some intuitive sense of what we are talking about. Space-time – or spacetime – is relatively new to the scientific vocabulary. Even though, throughout history, many cultures have had unified concepts that don't separate space and time, as a profession, physics conceived of them as distinct for longer than we have understood them to be unified.

And from my perspective as a science communicator, it is still an extremely difficult concept to explain. Even trying to describe "space" feels challenging. While writing this, I thought about saying that space is the place where motion happens. But in a sense, motion also happens in time. I could say that space is where things live, but again, I suppose a similar statement could be made about time. I also thought about saying space is a site of geography, but that sounds both very academic and tautological. It just means space is the site of space-type things.

To really talk about space and time is to rely on an intuition I presume you have. So let's say that space has three dimensions that we move about in, and time has one dimension that we move in but only ever in one direction.

But, as Albert Einstein famously pointed out, these aren't really separate phenomena. Especially when moving close to the speed of light, observers moving at different speeds won't necessarily agree on when events happen. They may also disagree about the size of objects. To really grasp all this would require us to measure space-time, rather than space or time separately.

> **"It's worth thinking whether space-time is a merger of two familiar phenomena or something new"**

This doesn't necessarily feel natural, but it is the best way to make sense of how things work.

In this context, it is worth thinking whether space-time is a merger of two familiar phenomena or something new. This is where the grammar comes in as a reflection of our scientific sensibilities, at least for me.

My last name contains the first hyphen I ever met: my parents decided I should carry both of their last names. So to me, Prescod-Weinstein means I am a Prescod and a Weinstein.

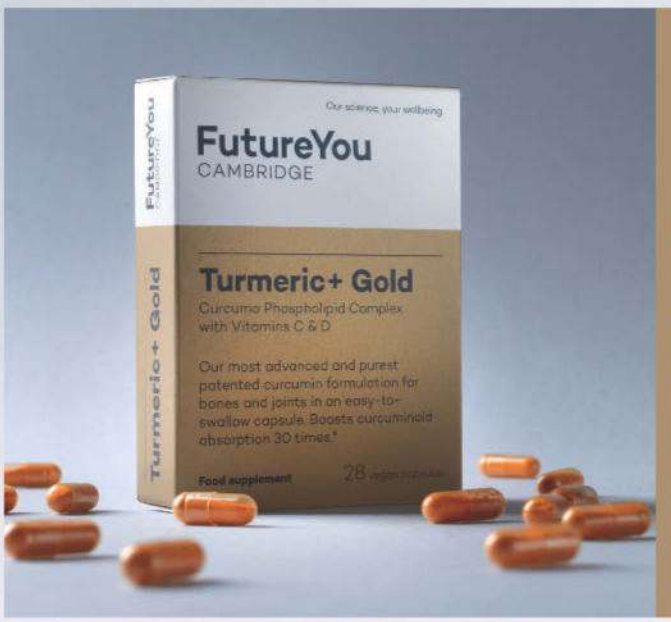
The hyphenated version of space-time can be read as signalling that the phenomenon we are describing is both space and time. Alternatively, dropping the hyphen to render it as "spacetime" could suggest that we are talking about something completely new. Something that has features of space and time, but is a third, separate thing.

So, are we dealing with something that is space and time – a space-time – or are space and time just approximations for the completely different concept of spacetime? I am a bit of a fence-sitter. My first book, the blurb-writer pointed out, didn't use the hyphen, which raises the question of why I made the switch.

The easy answer is that the title of the new book appears in the early pages of a classic textbook about cosmology, *The Large Scale Structure of Space-Time* by Stephen Hawking and George F. R. Ellis. At the very start of the first chapter, Hawking and Ellis argue that solving the equations that describe the universe "involves thinking about the edge of space-time in some sense". Two pages later, they say that singularities, places where the equations break down (such as the centre of a black hole), can be thought of as "representing part of the edge of space-time".

In my book, I have a chapter where I explain what kinds of equations they are talking about and the importance of boundaries and edges in physics. And since I was going to borrow this phrase for the title of my book, I had to commit and spell things the way they did.

That's the easy answer. But more deeply, I don't know which side I am on. I guess, like my blurb-writer, I lean towards spacetime without the hyphen. But I have no idea how much of that is force of habit from typing out the subtitle of my last book so many times. Scientifically, I think I am inclined to say that space-time is space and time – and also a third thing, spacetime. This may be a very quantum-mechanical answer, but I want it to be both simultaneously! ▮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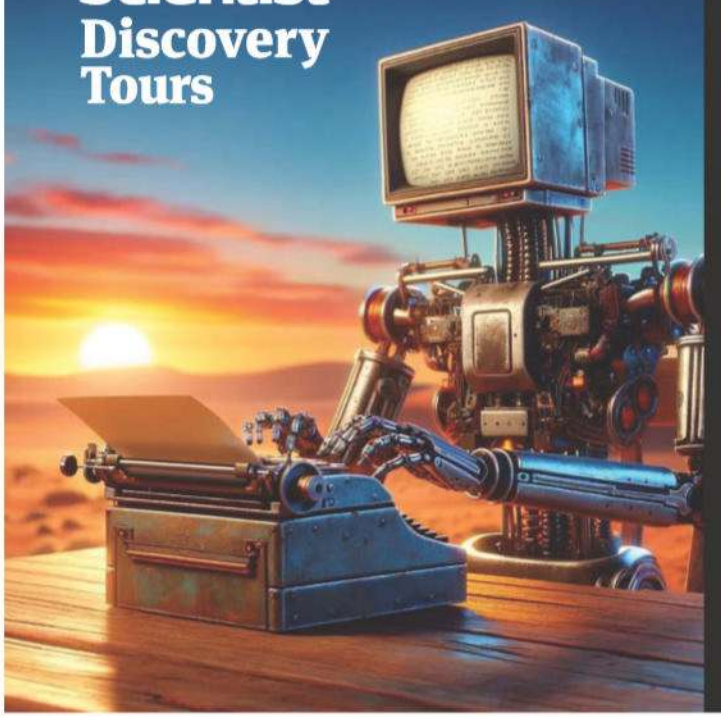

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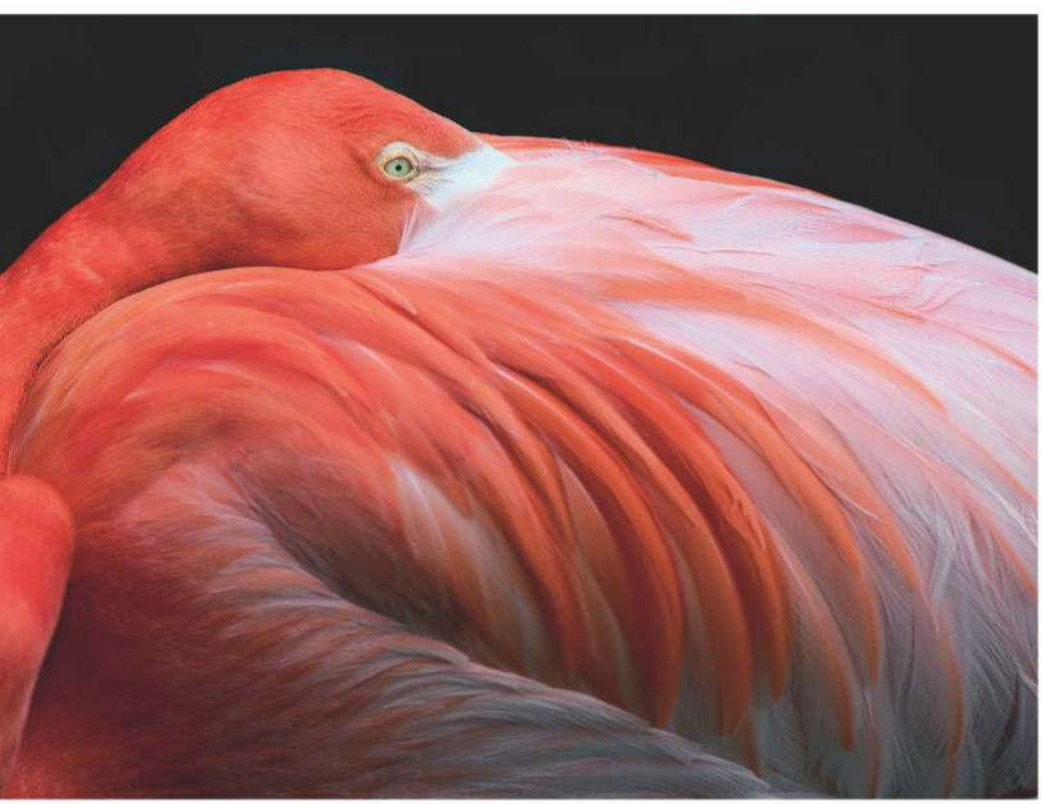


Feather focus

Thames & Hudson

BIRDS aren't easy to photograph – they are quick, flighty and prone to fickleness. But their resplendent colours and prismatic feathers have long enticed those behind the lens. Now, a collection of images that gathers the work of more than 50 photographers from around the world is putting birds centre stage.

Aviary: The bird in contemporary photography is an odyssey of more than 200 pages through the world of these winged wonders. Most books on birds are organised by species, habitat or physical traits, but *Aviary* takes a different approach. The collection has six themed chapters celebrating the relationship between humans and birds through imagined theatrical "acts", such as "sanctuary" and "encounter". The result combines several different fields, including art, fashion, documentary-making and ornithology.

Some images are striking in their simplicity, while others are bewildering in how they capture movement and detail. Trailed by a streak of iridescent blue, a kingfisher is frozen in time as it plunges into tranquil water (far left), photographed by Mario Cea.

In an image by Alan Walker (upper near left), two red-crowned cranes – among the largest and rarest birds in the world – throw their heads back in a courtship ritual as snow falls around them. In another, a vibrant flamingo, photographed by Robert Clark, rests its head on its feathers, which almost evoke the quality of an oil painting (lower near left).

Aviary by Danáe Panchaud and William A. Ewing is available in the UK from 11 September and in the US from 14 October.

Corryn Wetzel

Heart to heart

Can psychoanalysis help us remove obstacles to lasting love? A captivating memoir reflects on 40 years of talking about relationships, finds **David Robson**

Book
Love's Labour
Stephen Grosz
UK: Chatto & Windus, out now; US: Random House, out 10 February 2026

WITH their expert knowledge of the human mind and its desires, you might expect psychoanalysts' relationships to be free from the chaos that characterises most of our romantic lives.

But about halfway through his compelling memoir *Love's Labour*, a reflection on over 40 years of conversations about love with his patients, Stephen Grosz observes a messy love quadrangle involving four of his colleagues. Seemingly, Susan and Paul are happily married; so are Cora and Martin. Grosz meets the couples regularly at academic conferences, until it transpires that Paul and Cora have been having an affair for two years.

The subsequent recriminations somehow go to the very heart of their field. "I'm sorry you never learned what being a psychoanalyst is really about," Susan tells Cora. "Having empathy. Caring for others. Repairing boundaries. Seeing reality. Not stealing a friend's husband." For Susan, psychoanalysis seems to be all about responsibility and self-control. Cora responds that she is doing what was necessary to fully "become herself". In her view, the aim of psychoanalysis is conscious and deliberate self-realisation.

Psychoanalysts can help couples articulate their relationship problems

Grosz meditates on these contradictions, and his conclusion is enigmatic. Psychoanalysis, he says, may achieve both these goals, but it shouldn't aim to do either. "Helping the patient, improving her well-being – these aims can disguise an unconscious wish to limit the patient's freedom," he writes. The psychoanalyst allows the patient to better know their own mind – but what they do with that information is their choice.

Sceptics may argue that psychoanalysis is inherently unscientific. After all, how can we test an intervention with no firm outcomes in mind? First developed by Sigmund Freud, psychoanalysis uses unstructured conversations to reveal unconscious processes driving behaviour, exchanges that may last for years and can include lengthy analyses of childhood. It is quite different from cognitive behavioural therapy, which uses exercises designed to change someone's immediate thoughts and actions, such as strategies to "reframe" events more positively.

CBT now tends to be the first line of treatment for many mental health conditions, but clinical trials suggest psychoanalysis is effective at enhancing people's well-being – even if that shouldn't, as Grosz claims, be its main aim. And *Love's Labour* provides a fascinating examination of this process in action, through the heartache of Grosz's patients and acquaintances.

"Grosz has been compared to Anton Chekhov and Oliver Sacks, which seems equally justified here"

Consider Sophie. When Grosz meets her, she is engaged but can't bring herself to send out wedding invitations, despite wanting the marriage to go ahead. She also has terrible dreams of her parents dying. Together, they eventually link this to her parents losing a baby before Sophie was born. She is scared of any change that might take her away from them.

Often, a person's problems arise from a fear of losing their sense of self. "There is a vital distinction to be made between surrendering to something (or someone) and submitting to it," Grosz writes. While submission is transactional and involves a loss of control, when two people surrender to each other, "they feel alive, empowered, accepted. They feel love."

You won't find simple ways to achieve this in *Love's Labour*. As the title suggests, love requires constant work, as we strive to understand both ourselves and the object of our affection.

Grosz is a captivating writer whose understated vignettes often capture the complexities of the human condition. One review of his first book, *The Examined Life*, compared him to Anton Chekhov and Oliver Sacks, which seems equally justified here. His storytelling is at its finest when describing the entanglements of his fellow psychoanalysts. Paul and Cora stay together until Cora's death from a fall. Grosz visits the family home as they sit shiva, a week of mourning. There, he finds Susan, comforting Paul.

It was an emblematic moment, Grosz writes, revealing all the contradictions love entails. "Susan and Paul had loved, hated, married and divorced. But even at this difficult moment, they were still a couple. Still doing love's labour." ▮

CARLES NAVARRO PARCERISAS/GETTY IMAGES

David Robson is the author of *The Laws of Connection: 13 social strategies that will transform your life*

How not to fix the internet

Nick Clegg's new book offers no insights into the online world he helped shape as a Meta executive, says **Chris Stokel-Walker**

Book

How to Save the Internet
Nick Clegg
Bodley Head (UK, out now; US, 11 November)

HUGO AMARAL/SOPA IMAGES VIA ZUMA PRESS WIRE/ALAMY

Nick Clegg, then working as an executive at Meta, addresses a tech summit in Portugal in 2021

I CAN pinpoint the moment when my brain refused to take in any more of Nick Clegg's new book, *How to Save the Internet*.

It was on page 131, after a banal look at a future family whose lives had been improved by artificial intelligence, followed by a one-two punch of block-quoted chunks, first from a Massachusetts Institute of Technology professor, then from an NPR article. I had to put the book down and walk away. I couldn't hold out any longer. It was all too dull.

But because Clegg is a former executive at Facebook-owner Meta who had a front-row seat during the firm's clashes with regulators – and was also the UK's deputy prime minister from 2010 to 2015 – I felt there had to be something to learn here, so I picked it up again.

In his time at the company, Clegg witnessed some of Meta's most consequential decisions across its platforms, such as the two-year ban placed on US President Donald Trump in 2021. He presumably has thoughts about the impact of Meta's policies. Indeed, in *How to Save the Internet*, he claims he will set out exactly what big tech has got wrong (and right) and how our online world can be pacified despite the growing influence of authoritarianism.

Yet the book plods on without much wisdom, full of paragraph-length excerpts of other people's journalism, research and even blog posts. When Clegg's rare insights do appear, they are at this level of incisiveness: "if businesses and other organisations can do more in a working day, and quickly and automatically get insights from the data they hold, this will help them operate more efficiently". Thrilling, this isn't.

Even the book's last chapter, in which Clegg outlines his grand plan to "save the internet", is crashingly obvious. "The most dangerous thing for the US to do is to carry on with business as usual," he writes in a world where Chinese AI model DeepSeek wiped $1 trillion off US stock markets in a day. Duh. A global deal to lock out China is needed, he says to a political readership that is already doing exactly that.

More compelling to me would have been an in-depth explanation of how and why Meta intervened after Trump supporters stormed the US Capitol in 2021, leading to the president's ban. Instead, we learn that CEO Mark Zuckerberg let Clegg make that call, and he opted for the suspension. That's it. Clegg was "acutely conscious that it was a big step for a private company, and one taken moreover without precedent and without a clear process to follow". Little of the process that was followed is outlined. It happened, we are told, but not shown.

Quite why the book leaves so brief an imprint on the mind becomes clearer when you consider the author. Clegg spent years as a politician, then a tech executive, two jobs in which the less you can share about yourself with the public, the better. What greater sign of his success in these roles is there than writing a book that poses endless rhetorical questions such as "What is the likely socioeconomic effect of AI? Will it make inequality worse?" without answering them?

The problem with *How to Save the Internet* is that it tells you nothing. Both in terms of positioning – ever the politician, there is little that Clegg is willing to commit to firmly – and in recycling the same tired tropes you have read elsewhere. The internet's roots are traced back to ARPANET and the military; AI isn't actually intelligent; social media connects the planet, which is good, but also bad because some connections involve insults.

This is an after-dinner speech printed en masse, a think tank report in better binding and a fancy jacket. Save the internet? Save yourself the bother. ▮

Chris Stokel-Walker is a tech writer based in Newcastle upon Tyne, UK

New Scientist *recommends*

Alexandra Thompson
Assistant news editor London

The one-person show **Every Brilliant Thing** at @sohoplace in London tells the story of a boy moving from childhood to adulthood, alongside his mother's struggles with depression.

He decides to remind her – and the audience – of every brilliant thing life has to offer: the scent of freshly cut grass, the taste of crispy duck with sticky plum sauce and the joy of receiving a gift you wanted but didn't ask for.

The cast of the play rotates – I saw Jonny Donahoe (pictured), who was fantastic – which gives me an excellent excuse to see it again. I left the theatre with a spring in my step and tears in my eyes.

DANNY KAAN

I'm also making my way through the *Outlander* book series, and am enjoying the eighth novel, **Written in My Own Heart's Blood**, which follows 20th-century time traveller Claire and her 18th-century husband Jamie through the American revolution. It's pure escapism – and a guilty pleasure I don't feel remotely guilty about.

The sci-fi column

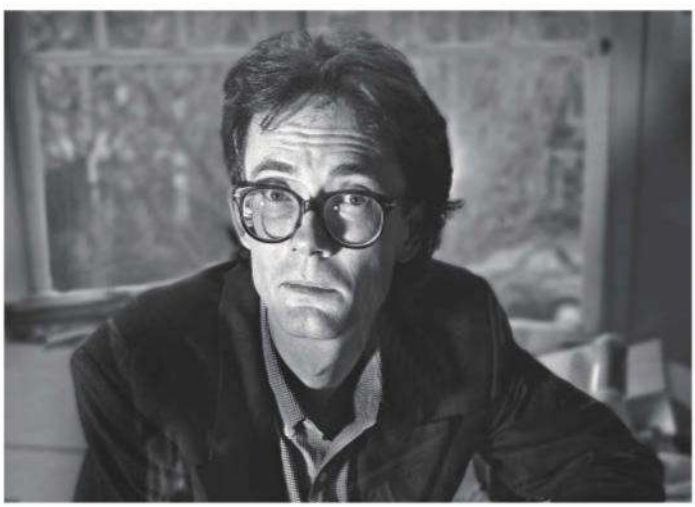
Electric dreams With a TV adaptation of William Gibson's *Neuromancer* arriving soon, it is a perfect time to revisit this prophetic cyberpunk novel. But have its imagery and conceptual verve stood the test of time, asks **Emily H. Wilson**

Emily H. Wilson is a former editor of *New Scientist* and the author of the *Sumerians* trilogy, set in ancient Mesopotamia. The final novel in the series, *Ninshubar*, is out now. You can find her at emilyhwilson.com, or follow her on X @emilyhwilson and Instagram @emilyhwilson1

Book
Neuromancer
William Gibson
Orion Publishing (UK); Ace Books (US)

Emily also recommends...

Book
Burning Chrome
William Gibson
Orion Publishing (UK); Gollancz (US)
Gibson's short story collection is astounding. It was one of my favourite books growing up, and it still sizzles today.



AARON RAPOPORT/CORBIS/GETTY IMAGES

William Gibson in 1985, a year after the prescient *Neuromancer* came out

NEUROMANCER begins with a brilliant, highly memorable line: "The sky above the port was the colour of television, tuned to a dead channel."

The novel was first published in 1984, when very few people had access to computers. Famously, William Gibson wrote the book on a typewriter. But despite this, it goes on to draw a vivid portrait of a futuristic world where data is currency and business is done in "cyberspace", though companies can also be hacked into and robbed. And, shimmering mysteriously in the background, there are powerful AIs that no one really understands.

Neuromancer instantly revolutionised sci-fi, giving birth to the cyberpunk genre, and more than 40 years later, it has proved to be one of the most prophetic books ever written. Now, it is being adapted as a series by Apple TV+. So how does the book stand up in a world where so many of us carry computers around in our back pockets, and time spent in cyberspace (a term popularised by *Neuromancer*) is the norm? I decided to revisit it to find out.

Not having read it in over 20 years, at first I found it hard going. Stylishly written, yes, but the claustrophobic account of an ex-computer hacker wandering between bars and getting in trouble with a gangster didn't seem that gripping. I began to wonder if the novel had failed the test of time. After all, its imagery and concepts are no longer new and astounding, having been copied so endlessly in TV, other books and film, as well as overtaken by real life.

But then it pulled me in. There is a scene where our hero is making a phone call from a hotel lobby when the next phone over suddenly rings... and it is an AI calling. It is a spine-tingling moment, and a reminder that *The Matrix* was extremely heavily inspired by *Neuromancer*.

The action shifts into space and we get to see more of the AI(s) up close. As I read on, I realised that the book's big concepts remain as relevant and thought-provoking as they were in 1984. One example: his idea of a force called the "Turing" that polices AIs.

By the end, I understood why people such as the author Adrian Tchaikovsky read and reread *Neuromancer*. You have to take it slow and pay attention, but it is a classic that still has so much to say. The question that remains is: how the heck did Gibson dream it up when his technology of choice was apparently a typewriter?

Fortunately, this is something he has had plenty of time to comment on in the decades since. "I was actually able to write *Neuromancer* because I didn't know anything about computers," he told *The Guardian* five years ago. "What I did was deconstruct the poetics of the language of people who were already working in the field. I'd stand in the hotel bar at the Seattle science fiction convention listening to these guys who were the first computer programmers I ever saw talk about their work. I had no idea what they were talking about, but that was the first time that I ever heard the word 'interface' used as a verb. And I swooned."

He went on to mention how his eavesdropping led to some nonsensical stuff in the novel, for example when the hero shouts: "Get me a modem! I'm in deep shit!" Of course, this was in the days when Gibson couldn't simply Google what a modem was.

In précis, the novel is fantastic. Let's hope the upcoming TV series does it justice.

Editor's pick

Thoughts on being an independent "otrovert"

16 August, p 19

From Sonia Novo, Halle, Belgium

The article about otroverts, a new personality type, really resonated with me. Growing up, I also felt pressured to join the Scouts, but I never wanted to and my parents respected that.

It was clear to me from a very young age that I didn't quite belong and that I didn't really care to. I completely agree with Rami Kaminski that this let me tread my own path without the constraints of any group's unwritten rules.

I also share his view that otroverts can and do form meaningful connections with others. Without the pressure to please members of a group, we don't have bonds with others just because "we're all part of the pack"; instead, we are free to expend more energy creating real bonds with those we are truly fond of. I am glad to see this recognised as simply a different way of seeing the world. But, to be honest, my happiness has never depended on it.

From Fred Zemke, Grover Beach, California, US

Kaminski claims we are all "born otroverts". How does this fit with the common observation that babies interact and form bonds with others from a young age?

High-speed interstellar missions may be risky

16 August, p 13

From Wai Wong, Melbourne, Australia

There is a major problem for a spacecraft travelling at relativistic speeds, as suggested in the proposal for a mission to a black hole: damage by particles in space.

At such speeds, any particle that a craft collided with would be like an energetic cosmic ray particle carrying kinetic energy more than a million times bigger than the dissociation energy of the strongest chemical bond. Even though the density of matter in intergalactic space is as low as an atom per cubic metre, an object moving at a third the speed of light can encounter 100,000,000 atoms per square metre per second, or about 10,000 times the rate of cosmic ray particles hitting astronauts and satellites in space. Could the thin sail and delicate electronics of such a fast probe survive 75 years in space?

The campaign for lower loos begins here

9 August, p 38

From Penny Wilde, Hull, Yorkshire, UK

After suffering a bladder prolapse, I was told the importance of not straining on the loo, lest it happen again. Consequently, I researched the subject, bought a folding squat stool and included as much fibre as possible in my diet. The improvement has been huge.

Something of great importance that doctors never told me is your position during the act: lean forwards and keep your knees up and apart. It leads me to believe that another reason why so many more women than men have issues with constipation could be because they are shorter. Perhaps toilets are made to a height that generally suits men, and for ladies to be best-positioned, they need to be lower. I can feel a growing movement calling for lower loos.

A reminder that the end is nigh in a few billion years

16 August, p 32

From Daniel Dresner, Manchester, UK

Leah Crane suggests donning a spacesuit in her look at the solar system. I did do this, but that was back in 1969 to re-enact the moon landings. In my collection of *How and Why Wonder Books*, there was a volume about the solar system. The final page described how the sun would expand over the next few billion years, and it scared the willies out me.

I have calmed down since then, but now you have reminded me. And we are now 56 years closer to the end!

Start young for a healthy old age

16 August, p 28

From Geoff Harding, Sydney, Australia

Future biomedical research will probably provide years of better health in older age. However, to live long enough to enjoy this, young people must be encouraged to lead extremely healthy lifestyles. The obvious requirements are a healthy diet, minimal alcohol, no drugs of addiction and a consistent exercise and strength-maintenance programme. The brain should also be nurtured through continual learning and no excessive stress. Unfortunately, this may seem boring and challenging to some, but the benefits could be immense.

Path to pet dogs may have worked for other species

9 August, p 34

From David Fishel, Indianapolis, Indiana, US

The idea that our ancient ancestors raised wolf pups as pets and then harvested them makes perfect sense, an idea proposed as a route to eventual domestication.

Could our ancestors have also raised juvenile ungulates for the products they would yield as adults? I can easily picture a band of hunters discovering a baby deer near its slain mother and subsequently taking it in. I know from experience that white-tailed fawns easily bond with human caretakers. So it isn't a stretch to imagine similarly tamed deer following a band of palaeolithic hunters.

Thoughts on making reuse of waste profitable

2 August, p 27

From William Hughes-Games, Waipara, New Zealand

The ideas at the heart of *On Natural Capital* remind me of the relationship between externalities – the peripheral costs of producing goods not included in their price – and the economics of recycling.

My favourite example is plastics, which can be pyrolysed and turned back into alkanes that are then separated into their component parts. This process may not be profitable using our narrow definition of profitability. However, if you credit the recycler with the cost of the damage they mitigate by getting rid of these materials, I am pretty sure it would be very profitable. The same principle would make recycling a whole range of other waste materials economically desirable.

Public transport won't solve all our travel woes

Letters, 14 June

From Rosemary Sharples, Sydney, Australia

It is a myth that public transport is the answer to traffic woes. Public transport doesn't go everywhere. It doesn't allow for the user's choice of time, route or travel companions, and the most flexible form of public transport, taxis, is also the most expensive, so public transport isn't necessarily accessible to everyone. It has a place, for example in rush hour, but it isn't a panacea by any means. ▮

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Between order and chaos

A radical theory says the cognitive power of the human brain can be explained by its proximity to disorder. **David Robson** reports

Think back through your day and consider all the amazing tasks your brain has helped you perform. From brushing your teeth to eating your lunch and reading the words on this page, your thoughts, feelings and actions may appear to be the product of a finely tuned machine. Simply telling someone your name is a small miracle for electrical signals zapping across a 1.3-kilogram lump of jelly.

"You're pulling off one of the most complicated and exquisite acts of computation in the universe," says Keith Hengen, a biologist at Washington University in St Louis. Exactly how we achieve this complexity has puzzled philosophers and neuroscientists for centuries, and now it seems precision isn't the answer. Instead it could all come down to the brain's inherent messiness.

Researchers like Hengen refer to this idea as the critical brain hypothesis. According to them, our grey matter lies near a tipping point between order and disorder that they call the "critical zone", or – more poetically – the "edge of chaos". We can see the same kind of instability in avalanches and the spread of forest fires, where seemingly small events can have large knock-on consequences.

Systems teetering on this precipice are governed by precise mathematical principles, and it now seems that the same dynamics may also explain our minds' extraordinary efficiency and flexibility.

The idea that the brain's electrical signalling could somehow follow the same rules as natural disasters may sound absurd – but many neuroscientists besides Hengen are coming to the same conclusion. "Criticality offers a powerful framework for understanding brain function and dysfunction," says Karim Jerbi, a neuroscientist at the University of Montreal.

The hypothesis can predict the effects of mind-altering drugs and might help us to diagnose illnesses like Alzheimer's with greater precision. It may aid us in understanding why some people are smarter than others, and perhaps it could even explain the purpose of sleep – and the origins of consciousness itself.

Most excitingly, certain meditative techniques may allow us to shift our brains towards or away from the tipping point – with the potential to enhance our mental flexibility.

Critical theory

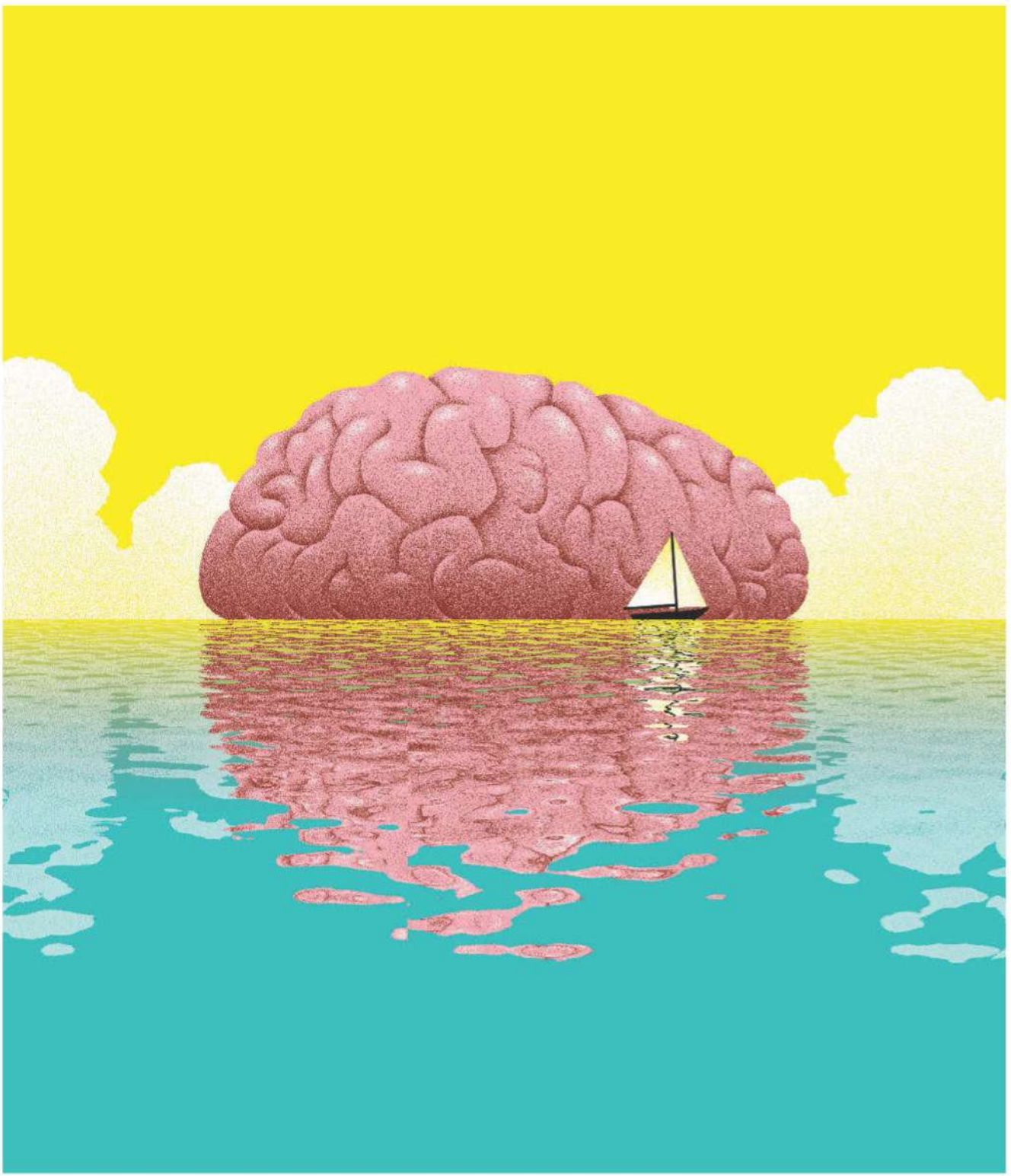
The seeds of the critical brain hypothesis can be traced back to Danish physicist Per Bak, who first outlined the laws governing critical systems in the 1980s and 90s. He found that the transmission of forest fires, for instance, lies on the cusp of a tipping point. Too far in one direction, and the whole ecosystem would quickly go up in flames, leaving no trees behind. Too far in the other, and each conflagration would die out rapidly, before any fire had a chance to spread.

Instead, Bak showed that forest fires tend to be "scale-invariant", meaning that fires of any size are possible. The exact frequency, he showed, follows a "power law", which means smaller fires are more common than larger fires according to a ratio that depends on factors like the climate and terrain.

By the early 2000s, neuroscientists had begun to suspect that the brain's electrical activity demonstrates a similar pattern. Our neurons are connected in intricate networks of synaptic connections, and when any cell "fires", it can trigger other cells to fire in response. "Activity builds on itself much like an avalanche," says Jordan O'Byrne, Jerbi's PhD student at the University of Montreal, who recently published a paper reviewing the mounting evidence for the critical brain hypothesis.

This chain reaction sounds exactly like the kind of system that might straddle the tightrope between order and disorder. To test the idea, John Beggs, at Indiana University in Bloomington, and Dietmar Plenz at the US National Institute of Mental Health in Bethesda, Maryland, took slices from rats' brains and measured the electrical activity of neurons as they spontaneously fired within a Petri dish.

They found that, on average, each active neuron prompted just one other neuron to fire as a result of its signalling – a number that, according to the maths, represents the brain's tipping point. Much higher, and the ›



LUCA D'URBINO

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avalanches could spread uncontrollably; much lower, and activity would fizzle out before it really got started. The rat brain slices were showing exactly the kind of scale-invariance and power law distribution that characterise other critical systems.

Multiple studies have since identified signs of criticality in other forms of neuronal behaviour, like the synchronisation of different brain regions. It has also been observed across many different species, including zebrafish, cats, monkeys and – of course – humans.

Along the way, there have been a few contradictory results, however, with some researchers failing to find the characteristics of criticality – such as power laws – in their measurements of brain activity. According to Hengen, these controversies pushed scientists in the field to use more sensitive recordings of neural activity and more sophisticated mathematical techniques to analyse the results. "The sceptical groups are, in my opinion, the best thing that ever happened for studying criticality in the brain," he says. "They forced the field to dig deeper."

Connectivity and creativity

Working with Woodrow Shew, a physicist at the University of Arkansas, Hengen examined data from 320 existing experiments and showed that the apparently contradictory results could be reconciled with the hypothesis if you use new statistical tests of criticality. Their paper was published in Neuron, one of the most influential neuroscience journals, in June.

> **"Lying between order and disorder may help the brain adapt"**

Exactly how close someone's brain lies to a tipping point may depend on many different factors, such as the connectivity of the networks and the balance of neurotransmitters in our synapses. "There's a zone of healthy brain function around criticality," says Shew.

This helps us to adapt our thinking depending on circumstances. "It gives the brain some room to modulate its level of criticality dynamically in response to certain situations or tasks," says O'Byrne.

That the healthy brain, while awake, never seems to veer too far from criticality suggests it must carry some serious advantages. The first is the breadth of information transmission and processing. Thanks to the scale-invariance of critical systems, signals can be passed over both small and large distances, which enables communication both within and between many different brain regions. The result is vastly more computational power. "The brain can explore the entire space of solutions," explains Hengen.

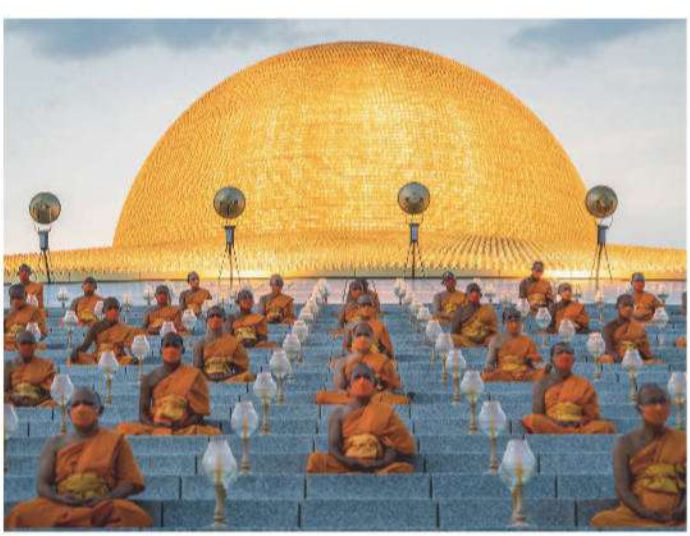
Lying between order and disorder may also help the brain to adapt to new situations. "It allows the brain to be both stable enough to make sense of the world and dynamic enough to optimally respond to it," says Jerbi. "We believe the brain operates near this edge of chaos because it's the ideal zone for complex thinking, learning, decision-making and adapting to new situations."

If this were the case, you would predict that small differences in the brain's proximity to the critical point would influence someone's overall cognitive function – and that is exactly what Naoki Masuda, now at the University of Michigan, and his colleagues found in 2020.

The team asked 138 adults to take tests to measure "fluid intelligence" – the ability to apply logic and reasoning to solving novel problems – which was then compared with measures of brain activity taken from fMRI scans. Sure enough, Masuda and his colleagues found that the brains of people with higher scores tended to lie closer to the boundary between order and chaos than those with lower scores – which is exactly what you would expect if criticality enhanced the brain's information processing and calculation.

The enhanced flexibility arising from the critical zone could be seen in an experiment by cognitive scientist Jaana Simola and her colleagues at the University of Helsinki in Finland. The participants had to play a computer game that constantly changed its rules, which required them to update their approach on the fly. The closer their brains were to the critical point, the better they performed.

Jerbi suspects the brain's proximity to the critical point may be especially important for creativity – a form of thinking that isn't measured in standard IQ tests. "Creativity emerges from the brain's ability to explore novel ideas while maintaining enough structure to make them meaningful," he says. "Criticality may provide the



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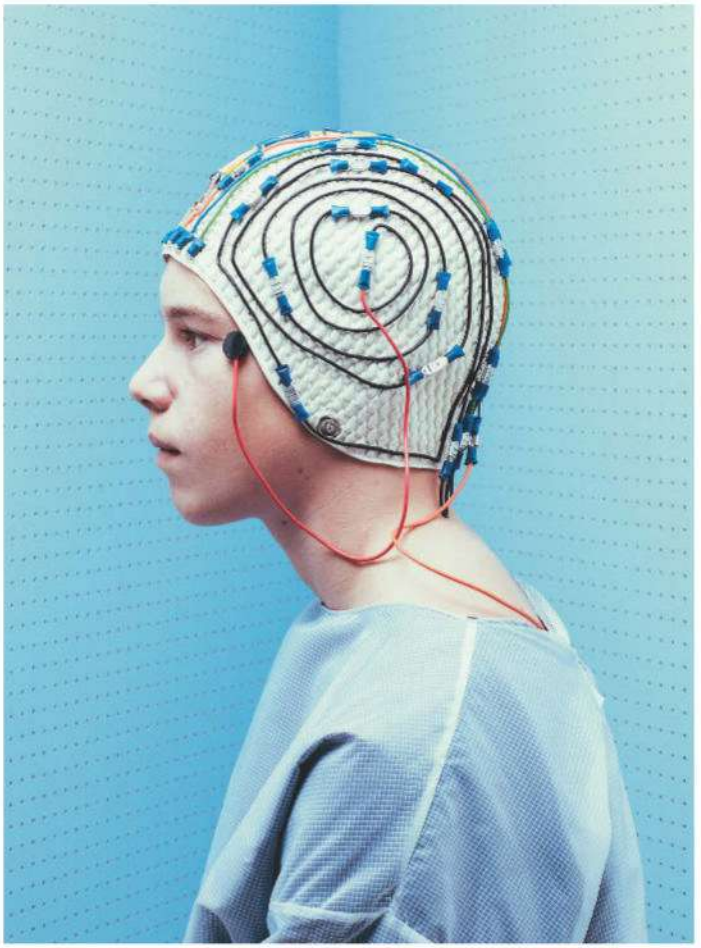
Certain types of meditation may edge the brain nearer or farther from criticality



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Brain activity closer to the tipping point between order and chaos is correlated with intelligence

optimal neural environment for this process, allowing the brain to shift fluidly between spontaneous, divergent thought and focused, goal-directed reasoning."

Large departures from the critical zone – either into order or disorder – may result in serious brain dysfunction. "While criticality gives the brain its edge, it also means that small shifts – due to illness, stress or injury – can sometimes push it into less optimal or even harmful states," says Jerbi.

Alzheimer's disease is a case in point. Studies have shown that Alzheimer's-affected brains often suffer some serious damage before the patients begin to demonstrate a rapid decline in their thinking. This may mark the moment when the brain struggles to remain within the critical zone, producing a serious dip in its computational abilities. "There comes a point where, if you take out enough nodes from a network, you now really start to see the richness of the network fall right off," says Vincent Zimmern, a PhD student at Paris-Saclay University who recently authored a paper on the clinical applications of criticality.

Why we sleep

The potential implications of brain criticality have started to attract widespread attention from other neuroscientists. "General interest has been growing at an accelerating pace in recent years," says O'Byrne. "The word is getting out." And that has led to ever more ambitious proposals for what the phenomenon might explain.

Hengen, for instance, wonders whether sleep may have evolved to return the brain to its critical point. His studies of rats already provide good evidence that fatigue is intimately linked to the brain's criticality. "The strongest predictor of whether or not an animal is going to be awake or asleep in the next hour is its proximity to criticality," he says. "The closer you get to the critical point, the more likely you are to be awake. And the further you are from the critical point, the more likely you are to be asleep."

It seems that the longer we work the brain, the further it moves from the tipping point, while sleep helps to tune it back into the critical zone. Without that rest period, the brain would fail to reach its optimum state, resulting in the reduction of cognitive performance that has long been known to accompany insomnia. The length and quality of sleep can even influence automatic processes like breath control, says Hengen. Such widespread effects suggest that sleep evolved to address a basic underlying factor that governs all its processing – and that, he argues, is its proximity to the critical point.

O'Byrne is of the same mind. "One of the functions of sleep – and perhaps its most important function – may be to allow the brain's connections to be recalibrated and to return whole-brain dynamics to the critical point."

Chemical crutches such as caffeine may reduce fatigue by pushing the brain towards criticality, but that comes at a price. Jerbi's University of Montreal colleague Philipp Thölke recently invited participants to sleep in a laboratory on two separate nights. On one occasion, they were given 100 mg doses of caffeine – the equivalent of a strong espresso – 3 hours and then 1 hour before their bedtime. On the other, they went cold turkey. The researchers then asked them to wear an electroencephalography (EEG) headcap with electrodes that could measure their brain's electrical activity as they slept.

The team found that caffeine consistently moved the brain closer to the critical point during sleep. "It kept the brain in a semi-alert state," says Jerbi, a co-author of the paper, which was published earlier this year. The result may not be just a restless night; by reducing our time out, caffeine may prevent the brain from bouncing back to its full powers by morning. "It potentially interferes with the restorative functions of sleep."

Brain criticality could even help us unlock the enduring mystery of consciousness. It is a notoriously tricky concept to define precisely, but most neuroscientists and philosophers agree that, at its most basic, consciousness involves a "subjective perspective" – be that in real life or even a dream – that includes perceptions or mental images with distinct ›

qualities, such as colour and shape.

According to one leading hypothesis, called integrated information theory, this subjective perspective arises from the way data is processed and combined in the brain, so that the integrated total is more than the sum of its parts. Intriguingly, mathematical models suggest that measures of information integration peak when the brain approaches the critical point, which would mean that it is essential for the awareness of our thoughts, feelings and sense of self.

One way to test this theory has been to examine the effects of different anaesthetics. Xenon and propofol, for instance, appear to eliminate all conscious experience. Ketamine, by contrast, produces a state of dissociation that cuts the patient off from the outside world without removing awareness entirely. They can still experience vivid dreams that are filled with very strong sensations and a sense of self, for instance.

In a paper published last year, O'Byrne and his colleagues found that the brains of patients under ketamine remained near the critical zone, whereas the brains of those who had taken xenon or propofol moved away from the tipping point. "This seems to suggest that brain criticality is a necessary condition for consciousness, though more work will be needed before we can say this with more confidence," he concludes.

VCG/VCG VIA GETTY IMAGES

Sleep may have evolved to bring the brain back to its critical point

Fine-tuning our thinking

Given the role that criticality plays in our thinking, it is natural to wonder whether we can learn how to tune the brain's position within the critical zone. Wouldn't it be useful to edge the brain away from it before bed, for instance, or bring it closer to the tipping point when we need to process complex information or brainstorm new ideas?

Hengen is currently on the case. "Woody [Shew] and I are doing some cool stuff examining whether you can influence a brain's proximity [to] criticality in a way that promotes complex learning." He is coy about the details, though he says that it involves crafting sleep patterns – and that his experiments with animals are already revealing impressive results.

Another option is meditation, though we have to be careful about the specific kind we use. Practices like Samatha meditation, which involves intense focus on a single sensation, such as your breath, would lead the brain to move away from the critical point. "This makes sense, since criticality is a state of maximum sensitivity and flexibility, but during focused-attention meditation, you're trying to tune out distractions and 'crystallise' your mind in order to bring out certain important details," says O'Byrne.

"This suggests that brain criticality is a necessary condition for consciousness"

Vipassana, or open-monitoring meditation, on the other hand, encourages a non-judgemental awareness of all thoughts, feelings and sensations that pass through the mind. "Here, we would expect criticality to instead be increased, so as to become maximally sensitive to the environment," says O'Byrne. And a new study from Annalisa Pascarella at Italy's National Research Council provides tantalising evidence for this idea.

The participants were 12 Buddhist monks from the Santacittārāma monastery near Rome. Within the study, Pascarella asked the monks to engage in Samatha and Vipassana for 6 minutes each while she measured their brain activity with a magnetoencephalography (MEG) headcap – a technique that is similar to EEG but offers more data from across the whole cortex.

As hypothesised, the researchers found that the focused Samatha meditation moved the brain away from the tipping point, while the Vipassana open-monitoring meditation moved the brain towards it. "They were able to make their brains even more critical than during normal resting wakefulness," says O'Byrne, a co-author of the paper. The study is now available as a pre-print and is awaiting peer review. The results suggest that, with enough practice, it seems we can shift the brain's activity at will, allowing us to achieve the perfect state of mind for the task at hand.

It's worth noting that each monk had accumulated more than 2000 hours of meditation experience, but new technologies could eventually ease that process. Jerbi – who was also a co-author of the Buddhist meditation paper – points to something called neurofeedback. This presents users with a visual representation of the brain's activity, using portable EEG, as they practice, which is thought to speed up the training of certain meditative techniques.

In the meantime, we might simply learn to appreciate our slightly chaotic minds a little more. Those moments of mild scattiness may simply be a sign that we are sitting comfortably in the critical zone, with all the benefits that provides. ▮

David Robson is a science writer and author of *The Laws of Connection: 13 social strategies that will transform your life*

People can be a happy place. **Jo's** four children are his. His world is never bigger than with them. Out on a hike. Everyone together. It's when Perthshire is at its most beautiful.

But his favourite bit? When the walk is finally over and the whole family sits down for a proper cup of tea and ever-so-slightly overdone fruit cake.

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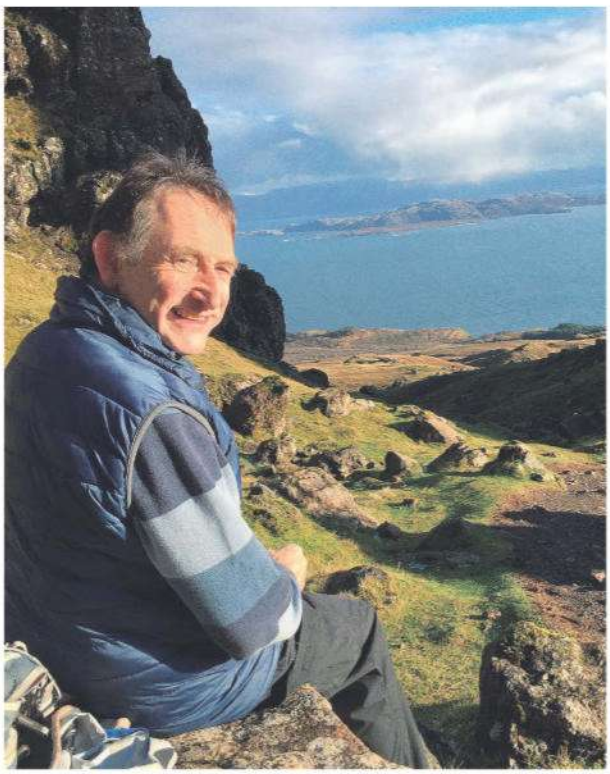

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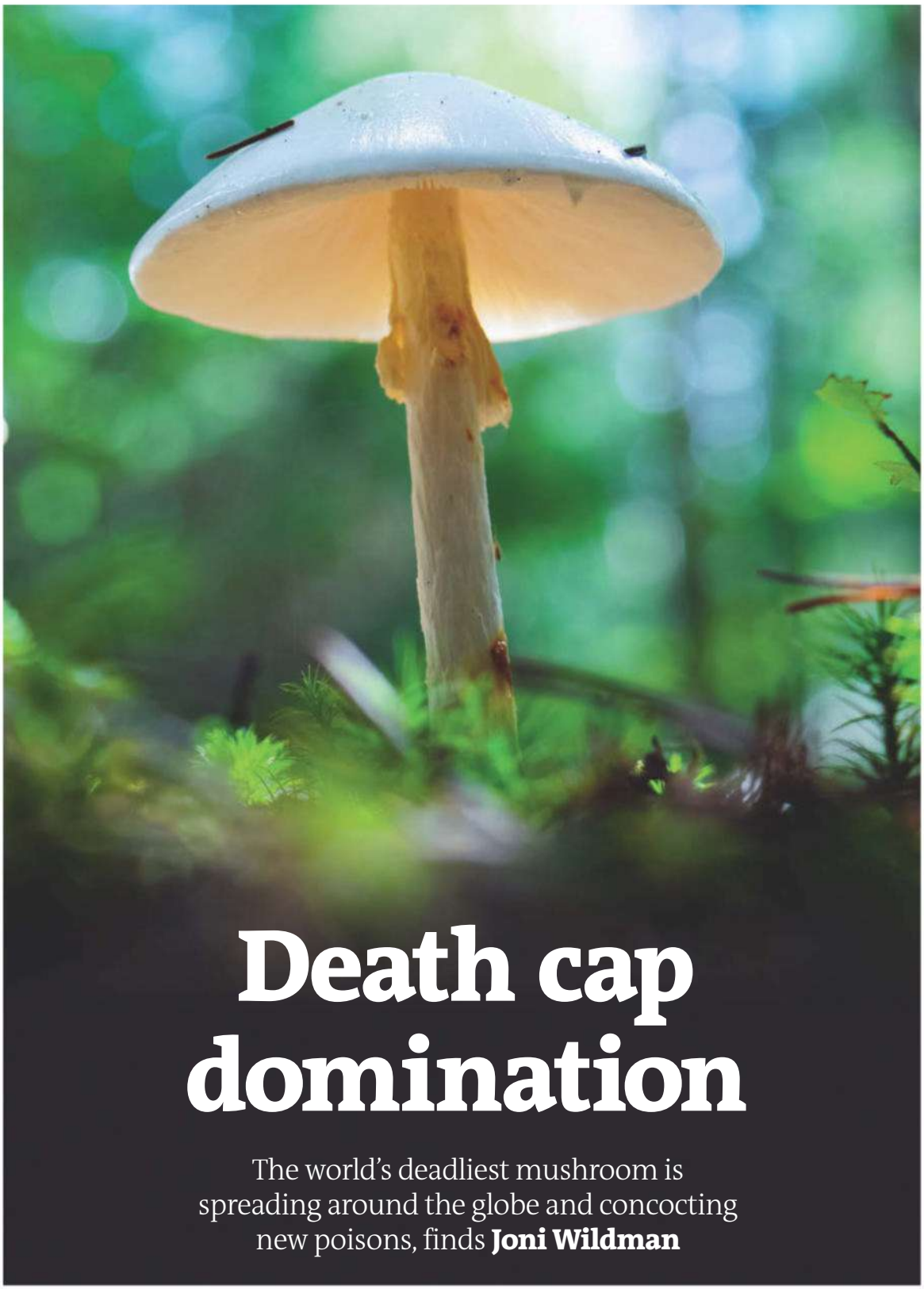

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Death cap domination

The world's deadliest mushroom is spreading around the globe and concocting new poisons, finds **Joni Wildman**

DEATH cap mushrooms are back in the news. *Amanita phalloides* has once again been linked to poisonings, this time lacing beef Wellingtons served at a family meal in Leongatha, Australia, which resulted in three fatalities. Such incidents inevitably reignite public fear surrounding this deadly mushroom – and mushrooms in general. The fact that death caps look so innocuous only adds to their malevolent mystique. With their pale yellow cap and white gills, they can be mistaken for several edible fungi – which might explain why they are responsible for almost all mushroom-related deaths. Just half of one is enough to kill you.

Headline-grabbing as it may be, the death cap is only one of many remarkable fungi. More closely related to animals than to plants, they form an entire kingdom of life, with an estimated 5 million species. Although just 5 per cent have been described formally, those we know of include some that are truly surreal. Cordyceps mushrooms (*Ophiocordyceps unilateralis*), for example, erupt from the bodies of ants that have been infected and zombified, while stinkhorns (*Phallus impudicus*) secrete a foul-smelling slime that mimics rotting flesh, and dead man's fingers (*Xylaria polymorpha*) emerge from forest floors as eerie black appendages.

In comparison, death caps appear nondescript. Nevertheless, their toxicity makes them the subject of active scientific research. And the results are fascinating: recent studies reveal a rapidly evolving species, generating novel toxins, thriving in new environments and spreading across the globe. These insights aren't just reshaping our understanding of the death cap, but of the entire fungal kingdom. What's more, they have the potential to shift public perceptions of fungi from fear to informed appreciation.

History is marked by a series of suspected death cap poisonings. The Roman Emperor Claudius may have been killed by a dish containing them in AD 54, possibly orchestrated by his wife Agrippina the Younger. The death of Pope Clement VII in 1534 has also been linked to death cap poisoning. Likewise, that of the renowned composer Johann Schobert. These are just a few from a catalogue of fatalities. Even when the evidence is unclear, *A. phalloides* is often the prime suspect, demonstrating how its deadly reputation has persisted over time.

Today, the death cap is responsible for approximately 90 per cent of mushroom-related deaths. "As little as 0.1 milligrams per kilogram of body weight can be fatal," says James Coulson, a clinical pharmacologist and toxicologist at Cardiff University in the UK. "Survival depends on the amount ingested... and the physiological reserve of the patient."

At least we now know how *A. phalloides* does its damage. Its most lethal toxin, alpha-amanitin, acts by blocking the enzyme RNA polymerase II, which is needed for transcription, a step in the process of protein production that is essential for the survival of almost all cells. If death cap mushrooms are ingested, alpha-amanitin is absorbed through the intestines into the bloodstream and travels to the liver. From there, it hides out in the gall bladder, a small organ nearby that contains the digestive fluid bile. The person who has been poisoned then begins to feel better and may decide to eat again. But that is when their problems multiply. When food enters the digestive system, the gall bladder releases bile into the intestines and, with it, the toxin. Alpha-amanitin is reabsorbed into the bloodstream and begins circulating through the body again. Each cycle like this causes further organ damage, especially of the liver, and can ultimately be fatal. "Apparent improvement is often followed by features of acute liver failure, hypoglycaemia, coma and clotting disorders," says Coulson.

Why the death cap needs to be so deadly is more of a mystery. Solving it isn't helped by the fact that it is extremely difficult to study. "The challenge in working with *A. phalloides* is that we cannot grow them... so a lot of genetic tools are off the table," says Yen-Wen Wang at Yale University. We do know that alpha-amanitin is a secondary metabolite, meaning it isn't essential for the fungus's survival. However, producing secondary metabolites requires energy and resources, so the toxin almost certainly confers some advantage; otherwise, it would probably have been eliminated through evolutionary processes.

Some scientists think that poisonous fungi evolved toxins as a form of chemical defence against being eaten before the mushrooms mature and release their spores. If so, then at least for death caps, humans are collateral damage: symptoms take many hours or even days to appear, which isn't quick enough to prevent the mushrooms from being consumed. Instead, alpha-amanitin probably serves the more immediate purpose of deterring mushroom-munching insects.

A. phalloides may also use poisons as a form of chemical defence underground. It is an ectomycorrhizal fungus, meaning it ›

The killer death cap mushrooms are rapidly evolving

DR MORLEY READ/SCIENCE PHOTO LIBRARY

DAVID CHAPMAN/ALAMY

Cordyceps (above) sprout from zombified ants, while dead man's fingers grow up from the forest floor

forms a symbiotic relationship with tree roots, to which it provides nutrients such as nitrogen and phosphorus, while the tree supplies carbohydrates. Such partnerships have played an important role in the success of many fungi – they also help explain why many are difficult to cultivate under laboratory conditions. So, alpha-amanitin may have evolved to give *A. phalloides* a competitive advantage in colonising and maintaining access to tree roots by suppressing rival fungi and killing soil microbes and invertebrates that could cause it harm.

Alpha-amanitin is just one of a cocktail of toxins produced by death caps, and recent research has revealed that these poisons are still evolving – right now, and rapidly. This makes *A. phalloides* a model for studying adaptation and genomic innovation in fungi. "It informs us how toxins evolve and the ecological roles of these toxins," says Wang.

The first clues of this came when people started finding death cap mushrooms in new and diverse habitats on every continent except Antarctica. At first, researchers thought they might have been wrong to assume the fungus was native to Europe. But this idea was proved incorrect in 2009 when Anne Pringle, now at the University of Wisconsin-Madison, and her colleagues used historical records and DNA analysis to show that *A. phalloides* had been brought to North America from Europe on the roots of imported trees and became established once these were planted. What is particularly striking is that, as the death cap has spread from its native Europe to the US and the rest of the world, it is sometimes found associating with trees it would never have encountered in its original habitat – a sign of adaptation.

Toxic mycelinity

This is where the toxins come in. In 2023, a group of mycologists, including Pringle and Wang, published a paper showing that each mushroom carries a slightly different mix of toxin genes. Crucially, these variations aren't random: the genes are under strong natural selection, meaning they are being actively shaped by the environment in which the mushroom is growing. "In new habitats, *Amanita phalloides* may be encountering unfamiliar soil organisms or microbial competitors, and it seems to be evolving its chemical arsenal in response," says Wang.

But there's more. Pringle, Wang and their colleagues published another paper later that year reporting their discovery of an unprecedented reproductive strategy in *A. phalloides*. Typically, fungi reproduce sexually through the fusion of two genetically distinct individuals, a process that requires compatible mating types. However, a genomic analysis of death cap populations in California revealed that some individuals were reproducing unisexually, forming mushrooms from a single, unmated nucleus. These individuals were able to produce generation after generation of spores and persist in the environment for decades, sometimes spreading across entire forest patches.

This discovery challenged assumptions about how fungi in general reproduce. Until then, all wild mushrooms were thought to reproduce sexually; unisexual fruiting had been observed only in the lab under artificial conditions. "It is possible that most fungi can do both," says Wang, "but invasive populations provide a specific opportunity for us to observe them." Such flexibility would give fungi an advantage when adapting to a new environment because unisexual reproduction allows a single spore landing in a suitable environment to establish a self-sustaining colony. "If an organism can reproduce without a mate, it will be more likely to establish in the new range," he says. Indeed, this reflects a strategy seen in many successful invasive plants and animals: those that can reproduce both with and without a partner tend to colonise more quickly and spread more widely.

This reproductive flexibility, combined with the diversification of its toxin genes, helps explain how *A. phalloides* has adapted so rapidly to new environments across continents. It reframes the narrative from passive spread to active evolutionary change, which makes this global expansion a fascinating real-time case study in fungal evolution. "Studying the evolution of *Amanita phalloides* can reveal how these fungi spread and impact local ecosystems, allowing us to develop models to understand biological invasion," says Wang.

The idea of a deadly mushroom capable of colonising the globe, reproducing in multiple ways and evolving its toxin profile to remain lethal in new environments may sound alarming. Indeed, there have been cases of mistaken identity in areas where the death cap has only recently been found and where foragers are unaware of the level of caution required. And death cap poisoning is unquestionably serious. As yet, there is no widely available antidote – although in 2023, researchers in China found that a commonly used medical dye has the potential to be one.

"It's hard to overstate how integral fungi are across medicine, biotech and the environment"

Early intervention is essential, and that can be problematic because the initial gastrointestinal symptoms subside when alpha-amanitin hides away in the gall bladder.

That's the bad news. But once death cap poisoning has been diagnosed, there are several effective treatments. "Options include supportive care – fluids to correct hypoglycaemia – oral activated charcoal [to soak up toxins in the intestine] and benzyl penicillin to reduce liver uptake," says Coulson. Even without an antidote, the survival rate after ingesting death caps is now around 90 per cent. What's more, despite the mushroom's fearsome reputation, poisonings are extremely rare. "Between 2013 and 2022, the UK's National Poison Information Service received enquiries regarding 1195 suspected mushroom poisonings," says Coulson. "Only 28 of these were reported as relating to *Amanita* species." That's around three a year – and *A. phalloides* isn't the only toxic member of the *Amanita* genus.

Besides, if research on death caps tells us anything, it is that they didn't evolve to harm humans – they are simply part of a broader evolutionary arms race for survival. "Mushrooms are not dangerous in themselves; they are only dangerous when treated in a specific way – when we eat them," says Iona Fraser, a field mycologist and educator, who is a council member of the British Mycological Society. "Fearing fungi does us, and them, a disservice." Most mushrooms aren't poisonous; in fact, many are beneficial. "It's hard to overstate how integral fungi are across medicine, biotech and the environment, both historically and now," says mycologist Daniel Henk at the University of Bath, UK.

For a start, fungi play a central role in scientific research. "Yeasts are the models for eukaryotic biology," says Henk. This is a reminder that as fellow eukaryotes – organisms whose cells contain a nucleus – we are more closely related to fungi than we often think. In biotechnology, they are invaluable. "Fungi are a fantastic tool," he says. They have a wide and expanding repertoire, such as the fermentation of foods, the mass production of key chemicals such as ethanol and citrate, and sustainable building materials. Their ability to produce antibiotics to kill bacteria has been harnessed by the pharmaceutical industry since the discovery of penicillin, and fungi continue to be a potential source of new antibiotics in an age of drug resistance. Recent research has even identified alpha-amanitin as a possible revolutionary cancer treatment.

LABORATORY/ALAMY

Yeasts have a wide range of uses, from scientific research to bread-making (below)

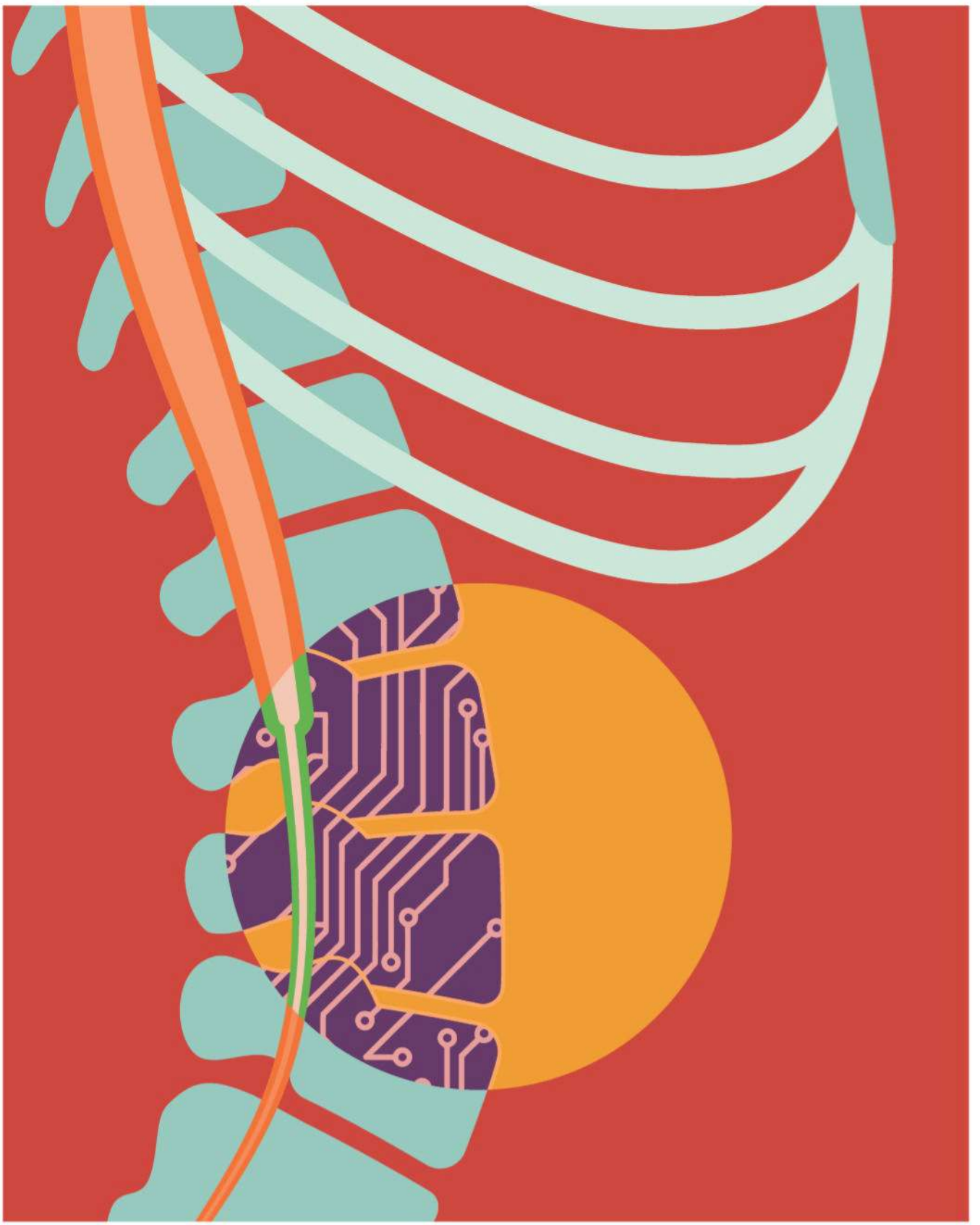
TREVOR MOGG/ALAMY

Fungi are also vital components of ecosystems. "They drive a lot of nutrient cycling through microbial communities and their often-symbiotic interactions with plants," says Henk. They can be used in ecosystem regeneration and can signal broad environmental shifts, including those driven by climate change. "Fungi are agents of change in ecosystems," says Fraser. Yet they are often ignored in ecological studies and conservation efforts, which leaves a major blind spot in our understanding of the natural world. And there is a darker reason why they warrant our attention, according to Henk: chemicals used to protect crops against fungal diseases are contributing to the emergence of resistant strains of fungi that can infect and kill humans. "Over a million deaths a year are attributable to fungi," says Henk, and only a few hundred of these are from eating toxic mushrooms.

We may feel helpless against the power of agribusiness, but at least we can control the personal risks stemming from poisoning. Around the world, many cultures respect and value mushrooms, combining traditional knowledge and ecological understanding to identify and avoid dangerous species. Fraser thinks foraging is a good way for anyone to educate themselves about the fungal kingdom and to appreciate it. She points to research showing that foraging also develops environmental awareness and a stronger connection to nature. Even for people who have no intention of eating fungi, there is immense value in observing them and "joy in interacting with mushrooms in nature", she says.

With more knowledge, perhaps the death cap will instil fascination rather than fear. The complex biology of this mushroom provides a window into the diversity, adaptability and ecological significance of an entire kingdom. It is evolving and, argues Henk, so must our attitudes. Compared with some disease-causing fungi, *A. phalloides* poses little threat; we should instead be concerned about the real dangers and benefits this branch of the tree of life can bring. "The fungal kingdom cannot be overlooked," says Henk. ▮

Joni Wildman is a mycologist at the University of Bath, UK



RYAN WILLS/ADOBE STOCK

Living electronics

A whole new class of implants that blend with our tissues promises to repair and even enhance our bodies – and last for far longer, says **Edd Gent**

IAN BURKHART was on holiday with friends in 2010 when his life changed forever. He dived into shallow water and broke his neck, leaving him paralysed from the shoulders down at the age of 19. "At that point, I was getting assistance with everything," he says, "even being able to scratch an itch on my forehead."

A few years later, Burkhart got an experimental brain implant that rerouted nerve impulses around his broken spinal cord to the muscles of his arm. It took time, but eventually he was able to use his hands and arms again – and even play the video game *Guitar Hero*. All in all, it worked pretty well.

Until, that is, it didn't. Because that's the thing about the implants we use to repair damaged or failing bodies: they don't last forever. That goes for devices of all kinds, including the 3 million or so pacemakers inside people's chests worldwide. Rigid, artificial hardware just doesn't sit well with the soft and squishy human body; eventually, the immune system turns against these foreign materials.

Now, however, a new type of electronics is being developed in labs around the world that might just change all this. The vision is for implants made from materials that bend, flow and even grow alongside our nerves and muscles, helping them to sit more harmoniously inside us. Some are built from soft, tissue-like materials. Others go further and blend living cells with circuitry. Together, they are forging a new class of "living electronics" that aim to not only last much longer, but also to one day help rebuild the body's lost connections.

We have known for centuries that electricity and biology are intimately linked. In the 18th century, Italian scientist Luigi Galvani provided the first concrete demonstration by making frog legs twitch with a jolt of charge. Today, we understand the human body runs on subtle electrical impulses that drive everything from heartbeats to wound healing.

Modern implants tap into this circuitry. Pacemakers maintain the heart's rhythm. Deep brain stimulators send electrical pulses into our brains to alleviate symptoms of Parkinson's disease. Cochlear implants can stimulate nerves in the inner ear to restore hearing. Efforts are also under way to develop retinal implants that reinstate a person's sight.

How well the body copes with these devices varies wildly. Pacemakers are usually tolerated well, lasting up to 15 years until their batteries need to be replaced, but deep brain stimulators generally need to be replaced every three to five years. Burkhart's experimental brain implant was a record-breaker at the time, lasting an impressive seven years before it had to be removed.

Cuts and tears

These implants are all bedevilled by a common problem: the immune system. Most tissues are soft, and rigid electronics can cut through them like a blade, says Jia Liu at Harvard University. Over time, this causes tiny injuries. The immune system responds, inflammation follows and, eventually, scar tissue surrounds the implant, degrading its signal and sometimes forcing its removal. Our tissues constantly writhe around and can change in shape and density as we age, all of which compounds the problems. Stiff devices just can't keep up, slipping out of place or tearing surrounding tissue, which triggers further immune attacks.

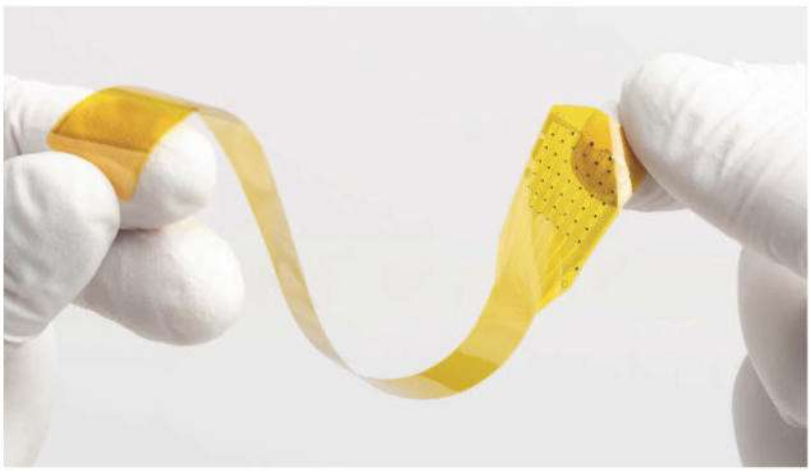
One straightforward fix is to make these implants softer. Several companies have embraced this approach, including Elon Musk's Neuralink, which makes a thread-like brain implant, and Precision Neuroscience, whose electrode arrays are encased in a soft, film-like polymer that rests on the brain's surface.

Liu's lab is pushing further. It has created an electrode thread so soft that it is almost invisible in water, yet tough enough to survive implantation and the harsh chemicals used in manufacturing. Crucially, the device can pack in almost 100 times as many electrodes per thread as Neuralink's, boosting the amount of data that can be recorded or transmitted. The probe causes minimal immune response, and Liu thinks that could allow it to remain effective for much longer than implants like Burkhart's. His start-up, Axoft, recently completed a clinical trial demonstrating that the probes could be safely implanted in human brains and record neural information.

Still, softness isn't the only route to successful implants. Early in her career, Rylie Green at Imperial College London was working on ideas similar to Liu's. But, in around 2012, she watched a sci-fi show featuring organic space stations that grow arms to connect with docking spaceships. That got her thinking. "Why can't our devices grow into the tissue?" she says. "Instead of sitting there and waiting for the body to respond, why can't we have a more proactive device?"

She and her team have now developed a tiny probe designed to do just that. At its core is a small circular platinum electrode that is coated in a jelly-like hydrogel – a soft, flexible material that can absorb and store fluids, and that feels a lot like biological tissue. Green's team seeds this with living neurons, which grow branches that connect with the host's brain tissue, while staying controllable from the device's electrode. Her group is developing implants to read brain activity or deliver deep stimulation for conditions such ›

Precision Neuroscience's implant is designed to sit on the brain's surface



PRECISION NEUROSCIENCE

"Subtle electrical impulses drive everything from heartbeats to wound healing"

as epilepsy or Parkinson's disease.

At the University of Cambridge, George Malliaras is taking a complementary path, having exchanged ideas with Green for years. His approach merges two cutting-edge biomedical fields: bioelectronics and therapies that treat diseases by using stem cells to repair or replace damaged tissues. The strategy is like a Trojan horse. The idea is to cloak the bioelectronics in living cells that can provide a biological camouflage. That way, the implant can not only evade the body's immune systems, but also merge with existing tissues.

In a study published in 2023, Malliaras and his team created a flexible, film-like electrode and coated the end with a hydrogel seeded with stem cells. These cells were coaxed into forming muscle tissue and then the cell-coated end was sutured to the severed nerve ending of a rat's forearm. The use of tissue meant the body wouldn't reject the implant, says Malliaras, but it also prompted the rat's neurons to grow into the implanted muscle cells. This biological bridge allowed the team to record electrical activity from the rat's nerve at a resolution much higher than a standard electrode implant.

A bridge for nerves

The group is now working on an implant that can bridge the severed nerve completely, not just recording electrical signals, but restoring movement to a paralysed limb. In the long run, Malliaras envisions versions that can transmit signals both ways – sending movement commands out and bringing sensation back in, whether to and from a real limb or a prosthesis. He says the device is about three to five years away from being tested in people.

The benefits of biohybrid approaches may go deeper still. Researchers are already experimenting with transplanting stem cells into people with spinal cord injuries or neurodegenerative conditions. These cells can develop into many different types of nerve cells – but how they mature and wire up to other cells is heavily influenced by the body's internal electrical signals.

In adults, those guiding signals are mostly absent, says Malliaras. But biohybrid approaches could help to replicate these signals, and even speed up and control the regenerative process, he says. There is evidence that electrically stimulating stem cells can help guide how they differentiate, migrate and even function in the body. "We're using a very limited capability of electronics when we interface with cells today," says Malliaras. "I can envision bioelectronics 2.0, where you implant the electrode not just to control an existing neuronal system, but using electrical stimulation to rebuild the network and then control it."

That could open up the tantalising possibility of not just working around the kind of injury that Burkhart suffered, but of actually restoring the broken connections. The idea is more than just a dream. US start-up Science Corporation is dedicating significant resources to building a commercial biohybrid implant that it hopes could someday help repair connections in the most complex organ of all.

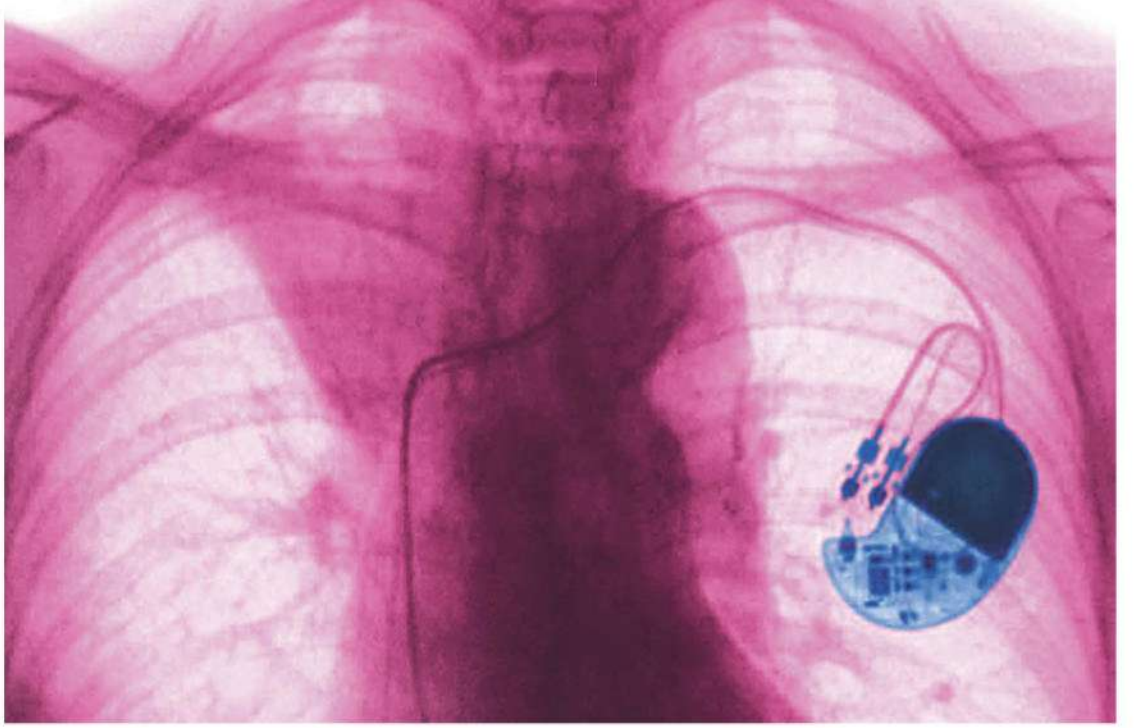
Alongside conventional brain implants and a retinal implant designed to restore sight, the company is developing a new brain implant that it hopes will surpass any silicon chip in terms of the data it can handle. The device starts with a honeycomb-like scaffold that nestles on the brain's surface. In each of its more than 100,000 tiny compartments sits a single neuron that has been genetically engineered to respond to light. Each gap in the honeycomb contains a tiny light source to activate the neuron and an electrode to record signals returned from the brain. Once implanted, the neurons would extend filaments that connect to neurons.

So far, this device has demonstrated the ability to send basic signals to a rodent's brain. But the long-term hope is that these individually controllable neurons could create general-purpose implants with many more connections than are currently feasible. Alan Mardinly, Science Corporation's director of biology, says he doubts conventional implant technologies will be able to get past a few tens of thousands of connections, but future biohybrid devices could reach the millions.

That could be transformative. Think of a patient who has a stroke and loses the ability to speak, says Mardinly. This may damage a brain region, but an implanted lattice of neurons, trained with patterned light, could take over its function. "We view it basically as putting brain-computer interfaces on a spectrum with regenerative medicine," he says.

Burkhart, who received his implant over a decade ago, has seen the promises and limitations of these experimental brain devices up close. He isn't won over by all the developments that people like Mardinly say are still a long way off. "I originally had my [device] implanted over 11 years ago," he says. "If you had asked me then where we'd be now, I would have thought we'd have a lot more success."

But Burkhart isn't sitting on his hands. He has assembled a group of early brain-computer interface (BCI) research participants called BCI



CAVALLINI JAMES/BSIP/UNIVERSAL IMAGES GROUP VIA GETTY IMAGES

Pacemakers can last for 15 years, but many other implants aren't so long-lived

Pioneers to ensure that big innovations in the field remain practical and scalable for real users. And he thinks brain implant technology has reached a tipping point, moving out of labs and into people like him.

Going native

Meanwhile, at the University of Pennsylvania, Kacy Cullen is working on what may be the boldest concept yet: throwing out the electronics entirely. He is developing what he calls "living electrodes" – devices built wholly from cells and tissue scaffolds, designed to integrate with the brain and function like native neural circuits.

Each consists of a clump of neurons genetically engineered to respond to light, perched on a slender hydrogel cylinder. The structure is implanted into the brain like a hollow rod, with the neural bundle remaining at the brain's surface. Over time, these neurons extend long filaments called axons down the tube, connecting with the cells deep in the host's brain. It is a biological relay that could bridge different brain regions or link the brain to external devices, like prosthetics or computers, all without triggering the immune response that dooms traditional implants.

And unlike electrodes made of metal, which can record inputs from only a handful of neurons, each biological cell can form thousands of connections. Different neuron subtypes use distinct neurotransmitters – chemicals that transmit signals – and form different types of junctions between brain cells, known as excitatory or inhibitory synapses, a variety that offers a richness and specificity that silicon can't rival. This could allow for a much finer level of control and potentially a higher bandwidth for communication to and from the brain via such a device, says Cullen.

But why stop there? "These engineered neuronal microtissues could potentially expand the computational capacity of the brain itself, effectively adding new layers of information processing to the nervous system," he says. In theory, that means more than just repairing damaged circuits – it could one day enhance memory or learning.

For now, though, this remains a distant goal, and the applications are more grounded. Cullen's lab received a grant from the UK's Advanced Research and Invention Agency (ARIA) to adapt the technology for Parkinson's disease. The aim is to rebuild a key neural circuit – the nigrostriatal pathway – that degenerates from the condition, depriving the brain of dopamine, a neurotransmitter.

His collaborators, led by Flavia Vitale at the University of Pennsylvania, are creating a biosensor that measures dopamine production in real time. This signal would feed into the living electrode, prompting it to adjust the amount of dopamine it produces.

"These engineered tissues could expand the capacity of the brain itself"

The approach could have applications beyond Parkinson's, says lab member Dimitris Boufidis, because many neurological and psychiatric disorders feature similar disruptions to brain circuitry. "You can think of it as bridges connecting different parts of the brain that get destroyed," he says. "What if we could rebuild these bridges?"

Green's team at Imperial has also received funding under the same ARIA grant to create a scaffold, seeded with neuronal stem cells, that can be injected into the brain to repair damaged circuits. Light and electricity will then be used to guide neuron growth and connections. Though an underlying disease could eventually also degrade repaired connections, Green says it is worth it. "At the end of the day, you buy people time and you buy people quality of life," she says.

Her lab is also exploring whether the same approach could help with traumatic brain injuries and spinal cord damage, like Burkhart's. "[We'd use] electrical stimulation to drive regeneration and drive connection, rather than bypassing the injury," she says.

Though Burkhart remains realistic about the time these things can take to reach patients, it is an approach that resonates with him. "If we can get something that allows someone to function the way they were able to function before a disease or injury, and just allowing them to be as independent as possible, that would be a huge benefit for those individuals and society as a whole," he says. ▮

Edd Gent is a freelance science writer based in Bangalore, India

The back pages

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Mathematics of life

Not so random

There are surprisingly useful mathematical patterns to be found in certain types of real-world data, says **Katie Steckles**

Katie Steckles is a mathematician, lecturer, YouTuber and author based in Manchester, UK. She is also adviser for *New Scientist*'s puzzle column, BrainTwister. Follow her @stecks

IF YOU were to look at the front page of a newspaper, you would probably find that it contains lots of numbers: amounts of money, population sizes, measurements of length or area. If you pulled all those numbers out and put them in a list, you would have a collection of random numbers.

But those numbers wouldn't be as random as you might think. In real-world data, like cash totals or the heights of buildings, the first digit in any given number is surprisingly likely to be 1. If the digits were truly random, around 1/9th would start with 1, but in practice, it is often more like a third. The digit 9 is least likely to lead the way, occurring roughly 1/20th of the time, and the other digits follow a curve between them.

This pattern, known as Benford's law, is a commonly observed distribution of first digits in certain types of datasets – particularly ones where the values are drawn from an unspecified large range. You don't see it happening with things like human heights (where the numbers all lie within a small range) or dates (where there are restrictions on the values the number can take).

But if you asked a group of people to check the amount of money in their bank account, or give their house number, or look up stock market prices (pictured), you might see the pattern – these are all numbers that could span several orders of magnitude. Some streets have only a few houses, while others have hundreds. This is why the phenomenon occurs.

MUHLA1/GETTY IMAGES

Imagine a street with nine properties: the proportion of house numbers starting with each digit would be an equal nine-way split. But in a street with 19 houses, more than half start with 1. These two extremes keep occurring as we increase the number of houses: with 100, there are roughly equal numbers of each initial digit; boost this to 200 and, again, half of them start with 1.

Since each item of real-world data comes from a set of unknown size, the average probability of a number starting with 1 ends up being somewhere between these two values. Similar calculations can be done for the other digits, and this gives us the overall frequency with which each appears. The effect is most visible in large collections of data.

One reason this is useful is that it gives you a clue when data has been faked. If you looked at a set of business accounts, you would expect to find Benford-like distributions in the sales figures. But if someone has fabricated data by picking random numbers, when you plot the frequencies of first digits, it won't have the characteristic curve. This is one trick forensic accountants use to detect suspicious activity.

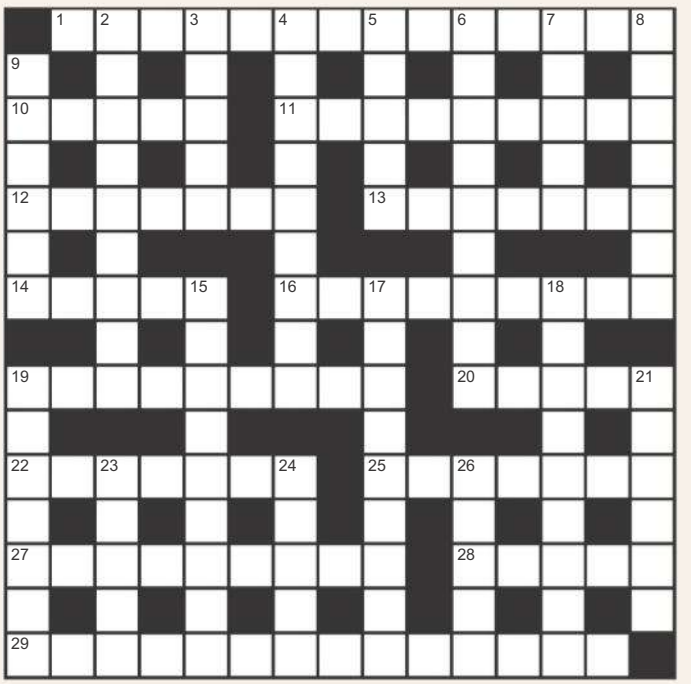
So next time you are checking your accounts or comparing the lengths of rivers, keep an eye on how many numbers start with 1 – you might just have spotted Benford's law in action! ▮

Mathematics of life appears monthly

Next week
Debunking gardening myths

These articles are posted each week at newscientist.com/maker

Quick crossword #191 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Rotating shaft with helical blades (5,9)
10 Extremely; beyond (5)
11 Most common blood group (1,8)
12 ___ shift, wave phenomenon (7)
13 Early ancestor of humans and monkeys (4,3)
14 Warning klaxon; reminder (to wake up?) (5)
16 3, 7 or 11, say (3,6)
19 Data indicating when a digital photograph was taken (9)
20 Sump (5)
22 Having two extremes (7)
25 Electronic token of admission (1-6)
27 Medicines that empty the bowel (9)
28 ___ Schrödinger, Vienna-born physicist (5)
29 Manhattan Project shock wave test (4,10)

DOWN

2 Cell material (9)
3 Online correspondence (5)
4 Gum disease (9)
5 Egg-shaped (5)
6 Type of bullet injury (4,5)
7 German optics company founded in 1869 (5)
8 European grazing mammal, *Capreolus capreolus* (3,4)
9 Arctic, Antarctic or alpine habitat (6)
15 Festive parasite (9)
17 Muscle type, as opposed to an elevator (9)
18 Australian bird; very rare event (5,4)
19 Cylindrical and hollow (7)
21 Floating or swimming (6)
23 Smallest element of a digital image (5)
24 Provoke into energetic motion (figuratively) (3,2)
26 Girder type (1-4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #318
set by Corryn Wetzel

1 What does the remote sensing technology lidar stand for?

2 What law describes how an electric current induces a magnetic field?

3 As of this August, Uranus has how many confirmed moons?

4 Each of your kidneys is made up of about a million filtering units called what?

5 What is the name of the first exoplanet confirmed to orbit a main sequence star?

Answers on page 47

BrainTwister
set by Daniel Griller
#89 Digit differences

In the number 3575, adjacent digits always differ by exactly 2.

How many nine-digit numbers (between 100,000,000 and 999,999,999) have the property that adjacent digits always differ by exactly 5?

How many nine-digit numbers have the property that adjacent digits always differ by exactly 4?

How many nine-digit numbers have the property that adjacent digits always differ by exactly 3?

Solution next week

In or out

Is it better to keep a fart or burp in, or let it out?

Peter Gibson
Professor of gastroenterology, Monash University, Melbourne, Australia
Farting in public is generally considered antisocial – worse, if it's smelly – and is a source of jokes and "cute" phrases such as "cutting the cheese" and "silent but deadly". Even the word "fart" is considered unacceptable or impolite in some situations, yet there is no other single word that best describes the act.

Everyone has gas in their gut, and most people fart multiple times a day, while many burp. The sources of the gas are what is swallowed normally (we all do it) or in association with fizzy drinks – some makes it through to the large intestine – and what our microbiota (bacteria and other microbes) in the large intestine make by fermenting carbohydrates (like dietary fibre) and protein. Some of the gases are used by the microbiota in the colon, some are absorbed into the bloodstream and are breathed out from the lungs, and some make their way to the outside world via farting or burping.

"To hold a fart or a burp in or let it out presents a balance between social acceptability and personal comfort"

How much gas an individual has depends on their diet. A high fibre intake will lead to more odourless gas, whereas higher protein intake may be associated with more smelly farts. Their microbiota, their physiology (how fast content moves through the gut for instance) and how much air is swallowed are also factors.

The vast majority of these gases are odourless: carbon dioxide, hydrogen, methane and nitrogen (from swallowed air). Some are not. The smelly gases are generally from the fermentation of protein and some other pathways associated with our microbiota. These are all normal. Our noses are exquisitely sensitive to malodorous gases, so farts need only a very small percentage of smelly gases to be detected.

If you suppress the urge to fart, the accumulation of gas in the bowel can cause problems, as shown in experiments where gas was bubbled into the bowel of healthy people and they were told to either fart on the "call" from their abdomen or to suppress the call and not fart. Those who didn't fart experienced pain and discomfort.

The gas stretches the wall of the bowel, and this stretch sends messages to the brain that will be interpreted as awareness, discomfort or pain. The interpretation depends on the tuning of the bowel (called visceral sensitivity) and the tuning of the brain. For example, people with irritable bowel syndrome have heightened visceral sensitivity (less gas may produce greater awareness or discomfort); a footballer during a match will suppress brain perception, and therefore be less aware of gas during the game.

To hold it in or let it out represents the balance between social acceptability and personal comfort. My opinion is that it is best to get it out in a socially acceptable place. Perhaps we should discourage the "unacceptability" of farting or belching (especially important for children during their impressionable years). No matter, the jokes will surely continue!

Peter Holness
Hertford, UK
Old as I am, one should never become too old to find burps and farts funny. I don't suffer from funny. I don't suffer from flatulence myself – I enjoy it! And a flippant question like this in a science magazine deserves answering both flippantly and scientifically. To that end, at the risk of sounding obvious, the answer to this question is: "It depends on the social and medical context."

As a teenage boy, I remember going around with other young men, drinking fizzy lemonade and sounding like bullfrogs as we competed to produce the longest, loudest burps. But an involuntary, throat-scorching, eggy belch at the wrong moment could easily sabotage a burgeoning romance. It might also indicate a medical condition requiring treatment, such as acid reflux or a stomach infection.

Anyone who has ever eaten a flatulent food item may have experienced discomfort that would be medically inadvisable to endure for too long. As such, the need to excuse oneself to let it out can become irresistible. It's bad luck if one is in a lift, though!

David Muir
Edinburgh, UK
Better an empty house than a bad tenant.

JACOB LUND/ALAMY

Why do we use high-pitched, silly voices when we speak to babies or pets?

This week's new questions

Baby talk **Why do we speak to babies and pets in cute, silly voices, as opposed to our normal speaking voice?**
***John Fredericks**, Queensland, Australia*

Weird water **How would the world be different if water didn't display a meniscus or surface tension?**
***Nick Sladek**, Bath, UK*

Sight unseen

Is short-sightedness found in other animals? Did it also affect ancient humans?

Simon McLeish
Lechlade, Gloucestershire, UK
There are animals that don't normally have good sight, such

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Tom Gauld
for New Scientist

I GOT TIRED OF HEARING ABOUT SO-CALLED "INFINITY POOLS", SO I CREATED A GENUINE ONE. THIS IS MY FIRST LENGTH.
GOOD LUCK!
IMPRESSIVE.

as moles, that rely much more on their sense of smell.

Similarly, there are bats that don't see well in the daytime, but compensate for that with their echolocation in the dark. And there are hawks that put our sight to shame.

There are, though, animals that have sight deficiencies similar to those in humans, in which a percentage of the species has poorer sight than the rest, such as horses. A Royal Society paper from 1894 found that more than 40 per cent of horses examined had myopia or astigmatism, and it was conjectured that myopia was a factor that can cause shying or startling. Similarly, a 1992 study found sight problems in dogs, with around 15 per cent of German shepherds being myopic.

In domestic pets, where animals often live to greater ages than their wild counterparts, the animals frequently experience similar problems as elderly humans, including deteriorating sight and sometimes blindness.

"A Royal Society paper from 1894 found that over 40 per cent of horses examined had myopia or astigmatism"

Peter Leach
Nercwys, Flintshire, UK
As I have been short-sighted since my early teens, I have always assumed that, had I been born as an ancient human, I would have been culled from the gene pool very quickly.

"Watch out for the sabre-toothed tiger, Peter!"

"What sabre-toothed tiger?"

Effortless ride

When driving over hills, which is more fuel-efficient: accelerating downhill for uphill momentum or maintaining a steady speed? (Continued)

Erik Foxcroft
St Albans, Hertfordshire, UK
One reader previously suggested disengaging the clutch when going downhill to save fuel.

"Coasting" or "freewheeling", as it is also called, is discouraged in the UK Highway Code, as it can reduce a driver's control over the vehicle. So, if you have an accident while coasting, you could be held more liable for any damage or injuries.

Coasting in a diesel or petrol injection-engined car will probably not save fuel, as the controller will cut the fuel to the engine if you take your foot off the accelerator going downhill anyway.

You will also wear out your clutch faster, and if you end up going faster, you may also wear your brakes more if you need them to slow down before you run up the next hill. So this isn't an ideal money-saving technique.

As others have said in previous answers to this question, the best way to take hills efficiently is to have a vehicle with regenerative braking, such as an electric or hybrid one. ▮

Answers

Quick quiz #318 *Answers*

1 Light detection and ranging

2 Ampère's law

3 29

4 Nephrons

5 51 Pegasi b

Cryptic crossword #169 *Answers*

ACROSS 1 Sable, **4** Flatter, **8** Redraft, **9** Rayon, **10** *Boops boops*, **13** IV tube, **15** Lysine, **17** Millimetre, **21** Flora, **22** Dataset, **23** Walleye, **24** Halve

DOWN 1 Scrubs in, **2** Badmouth, **3** Exams, **4** Fathom, **5** Atrophy, **6** Ttyl, **7** Rank, **11** Histosol, **12** Nepenthe, **14** Brigade, **16** Pledge, **18** Match, **19** A few, **20** Poll

#88 Double base *Solution*

The three expressions that produce a value the same as the corresponding binary number are:

5 – 4 + 7 = 8 (01000 in binary)

5 + (72 / 2) = 41 (101001 in binary)

279 × 4 / 9 = 124 (1111100 in binary)

Super wasps

One of Feedback's least favourite genres of news story is "reports that sound like foreshadowing from the first 5 or 10 minutes of a disaster movie". You know, stories with titles like "Tremors along seismic fault near major city", "Scientists create sapient robot with machine guns for arms" or "Giant mysterious black sarcophagus found in Egypt". (That last one is real, by the way.)

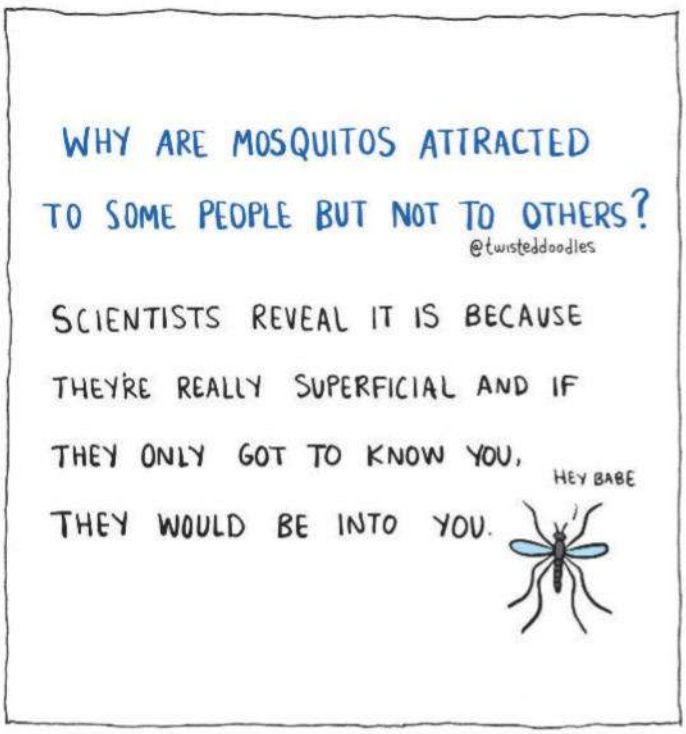
So we were more than a little horrified to see a BBC News report on 31 July headlined "Radioactive wasp nest found at old US nuclear weapons site".

The nest was found at the Savannah River Site near Aiken, South Carolina. The site produced parts for nuclear bombs during the Cold War, and is now home to tanks holding millions of gallons of liquid nuclear waste. However, investigators reassured everyone who would listen that none of the tanks had leaked. Instead, the nest had picked up "onsite legacy radioactive contamination", meaning residual contamination from when the site was being used to manufacture weapons-grade plutonium.

Apparently, the nest was sprayed to kill any wasps and then bagged as radiological waste. No wasps were found, which Feedback hopes is because they all died of radiation poisoning and not because they flew away to mutate in secret before returning to wreak havoc. We've seen enough Godzilla movies to know that animals consistently grow larger when exposed to radiation, regardless of the laws of biophysics, and 2025 is difficult enough as it is without a plague of giant radioactive wasps rampaging up and down the US eastern seaboard.

Just in case, Feedback pulled out our dilapidated copy of *New Scientist*'s book *Does Anything Eat Wasps?* Therein we learned that the striped insects are predated by other insects such as dragonflies and various birds including bee-eaters (duh, we guess), plus badgers and many more. We propose sending a clan of badgers to the Savannah River Site for radiation-induced giganticisation. It's the only way to be sure.

Twisteddoodles *for New Scientist*


WHY ARE MOSQUITOS ATTRACTED TO SOME PEOPLE BUT NOT TO OTHERS?
@twisteddoodles
SCIENTISTS REVEAL IT IS BECAUSE THEY'RE REALLY SUPERFICIAL AND IF THEY ONLY GOT TO KNOW YOU, THEY WOULD BE INTO YOU.
HEY BABE

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Consideration of items sent in the post will be delayed

Seeing high dogs

Reporter Matthew Sparkes was skimming press releases in search of potential stories when he came across one that asked a very direct question in its title: "What do you do if your dog ingests cocaine?" Upon being sent this, Feedback's immediate thought was "take it for a walk", but apparently that is neither helpful nor correct.

The press release refers to a clinical report about a chihuahua being brought into a veterinary surgery following an "acute onset of lethargy and a transient episode of unresponsiveness". Its urine contained "cocaine, cocaine metabolites, norfentanyl and trace amounts of fentanyl" – which would definitely leave Feedback feeling a tad lethargic. This cocktail had seemingly caused the dog's heart to slow, a symptom the veterinarians successfully treated.

So all was well in the end, however, Feedback can't help but imagine how much more infuriating a chihuahua – already the yappiest of yappy dogs – would be if it was high on coke.

Reading further, we learned that the dog had "a history of dietary indiscretion". Two things about that. First, Feedback can relate. Second, we were once acquainted with a rather dim-witted spaniel that would eat pretty much anything she found on the ground, regardless of how unsanitary it might be or the ensuing cataclysmic effects on her not-terribly-robust digestive system. Because of where we lived, this was mostly confined to old takeaway boxes and piles of fox droppings. But perhaps she might have ingested something more psychoactive if we had taken her for a walk in London's Soho.

Shorten, no matter what

Feedback often has to read through the lists of references at the end of academic papers, searching for vital context. They all look something like "Thomas, Richard & Harold, 'Something very complicated,' Nature vol 13 p 666 (1984)".

To save space, the names of the academic journals are often abbreviated, and while there are detailed rules governing the forms the abbreviations must take, the results can be impenetrable without some background knowledge.

Recently we were completely thrown when we came across a journal abbreviated as *Fish Fish*. Were its editors so keen on scaly water-dwelling vertebrates that they named their publication twice? Eventually we twigged that the journal was actually called *Fish and Fisheries*.

Our curiosity suitably piqued, we wondered if this was the most ridiculous journal title abbreviation.

There are some obvious trends. For instance, words like "analyses" are typically shortened to "anal". This is unfortunate for *Advances in Risk Analysis* (*Adv Risk Anal*) and it isn't great for *Accident Analysis & Prevention* (*Accident Anal Prev*) or poor old *Analytical Methods*. Likewise, a lot of journal titles include library-themed words like "bibliography". This explains why *Zeitschrift für Bibliothekswesen und Bibliographie* is apparently referred to as *Z Bibl Bibl*.

Some bullets have been dodged. The American Chemical Society has an entire series on *Advances in Arsenic Research*, but it didn't do the thing we might have expected.

The sheer number of journals, combined with Feedback's limited life expectancy, means we can't possibly find all the best ones. We therefore open up the quest for ridiculous abbreviations of journal names to the wider readership.

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